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REPORT ON SURVEY INVESTIGATION FLOOD CONTROL AND ALLIED PURPOSE--ETC(U)
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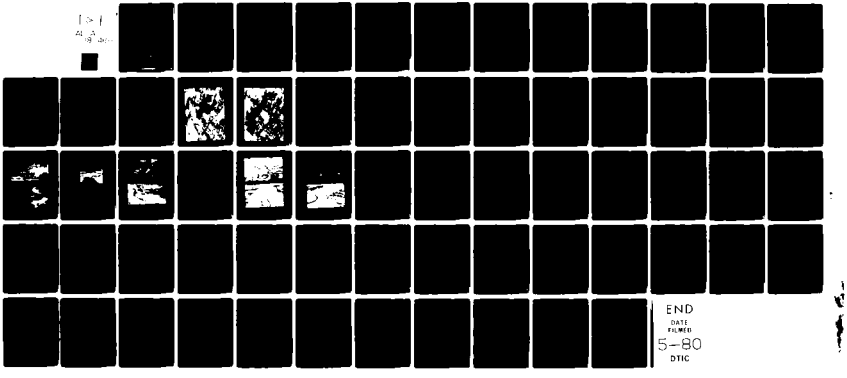

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REPORT ON SURVEY INVESTIGATION

FLOOD CONTROL AND ALLIED PURPOSES

IN

CAMDEN COUNTY STREAMS

NEW JERSEY

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

JUNE 1972

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): Report on survey investigation flood control and allied purposes along those streams that flow through Camden County, New Jersey into Delaware River.	5. TYPE OF REPORT & PERIOD COVERED: Report 6. PERFORMING ORG. REPORT NUMBER
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Camden County, New Jersey
Water Supply
Recreation
Delaware River
Navigation
Stream measurements
Flood protection
Water pollution
Sewage disposal

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The problems of water supply, water quality control, navigation, flood control and other related water and land resources along the streams that flow through Camden County, New Jersey into the Delaware River were considered during the course of the study. It has been determined that the primary need of the study area in the field of water resources is for flood control. Alternative measures, both structural and non-structural, were considered for the purposes of satisfying that need.

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Local protective works and modification and replacement of hydraulically inadequate bridges and culverts would be the most efficient structural measures for the protection of the reaches of the streams subject recurrent flooding.

Economic statistics and hydrological data for the study area is provided in the report.

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* U.S. GPO: 1974—540-847/9052

REPORT ON SURVEY INVESTIGATION
FLOOD CONTROL AND ALLIED PURPOSES
ALONG THOSE STREAMS
THAT FLOW THROUGH CAMDEN COUNTY
NEW JERSEY
INTO DELAWARE RIVER

Approved for public release;
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Prepared by

U. S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
CUSTOM HOUSE - 2d & CHESTNUT STREETS
PHILADELPHIA, PA.

SYLLABUS

The problems of water supply, water quality control, navigation, flood control and other related water and land resources along the streams that flow through Camden County, New Jersey into Delaware River were considered during the course of the study reported upon herein. It has been determined that the primary need of the study area in the field of water resources is for flood control. Alternative measures, both structural and non-structural, were considered for purposes of satisfying that need.

It was found that all feasible potential sites for flood control reservoirs have already been developed for recreational purposes. Potential sites for location of tidal barriers have inadequate area available for ponding of storm water runoff. Therefore, local protective works and modification or replacement of hydraulically inadequate bridges and culverts would be the most efficient structural measures for the protection of the reaches of the streams that are subject to recurrent flooding.

The nature and magnitude of recurrent flood damages that could be prevented along the tidal reaches of the streams are not commensurate with the costs that would be associated with providing flood protection through structural measures. Therefore, Federal participation in construction of structural measures for flood protection along the tidal reaches of the streams in the study area is not economically justified.

To a great extent, the hazard of flooding has been, and is being, disregarded in the construction of new residential communities along the non-tidal reaches of the streams. Improvement of the drainage systems for disposal of storm runoff has not kept pace with the rapid change in the nature of development from rural to urban. Channel capacities have been reduced by encroachments for residential developments, silting of culverts and the accumulation of debris. In view of the nature of, and the solution to, the flood problems along the non-tidal reaches of the streams, the matter of providing flood protection for those reaches must be considered the responsibility of local interests.

In lieu of providing structural measures, flood damages and damage potential could be reduced through adoption by local interests of non-structural measures that include a flood forecasting system, a flood proofing program and flood plain management programs.

The District Engineer recommends that local interests: improve the drainage systems for disposal of storm runoff along the upper reaches of the streams in the study area; restore, maintain and coordinate the operation of outlet controls at dams across the streams; initiate a flood forecasting system; undertake a flood proofing program for existing structures, and adopt regulations establishing flood plain management programs.

REVIEW REPORT

CAMDEN COUNTY STREAMS, NEW JERSEY

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DEPARTMENT OF THE ARMY
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IN REPLY REFER TO
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SUBJECT: Review Report, Camden County Streams, New Jersey

Division Engineer, North Atlantic
ATTN: NADPL-F

AUTHORIZATION AND PURPOSE

1. AUTHORITY. This report is submitted under the authority provided by a resolution adopted by the Committee on Public Works of the United States Senate on 8 October 1962. That resolution states:

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on the Delaware River and its tributaries, Pennsylvania, New Jersey, and New York, published as House Document Number 179, Seventy-third Congress, and pertinent reports with a view to determining whether improvements in the combined interest of flood control, navigation, water supply, recreation, water quality control, and other related water and land resources are advisable at this time, with particular reference to Cooper River, Pennsauken Creek, Big Timber Creek, and other streams that flow through Camden County, New Jersey into the Delaware River."

2. The Chief of Engineers by 1st indorsement, dated 15 October 1962, on the letter from the Committee of Public Works transmitting the resolution, authorized the Division Engineer, North Atlantic, to prepare a survey report under the above-quoted authority. The Division Engineer by 2d indorsement, dated 17 October 1962, assigned the review of reports to the District Engineer, Philadelphia.

3. PURPOSE. The purpose of this study was to make an investigation of the flood control, navigation, water supply, recreation and water quality control needs, and of other related water and land resource problems along the streams that flow through Camden County, New Jersey

into Delaware River. It was also the purpose of this study to determine the most feasible means, both from the economic and the engineering viewpoints, of meeting those needs and alleviating the attendent problems.

4. EXTENT OF STUDY. This study was of survey scope to determine the needs, the type and scale of improvements required to meet those needs, the degree of economic justification, and the equitable sharing between Federal and non-Federal interests of the costs and responsibilities for providing improvements. Field investigations and reconnaissance by the District Engineer and staff members were made of all areas where serious flood problems had been reported. A field reconnaissance was also made of all potential reservoir sites to identify those that might be suitable for providing storage capacity for flood control or water quality control purposes. Available maps, topographic data and foundation data were reviewed and additional field reconnaissance was made where further data were required. Studies included preliminary design of plans of improvement, investigations of hydrologic and hydraulic aspects, and cost estimates for providing improvements. Contact was made with Federal, State and local authorities to obtain available data and to ascertain their views regarding desired improvements. A public hearing, at which the views and desires of local interests were solicited, was held in Camden, New Jersey, on 30 March 1964.

DESCRIPTION

5. LOCATION AND EXTENT OF STUDY AREA. The study area is located along Delaware River in the western portion of south-central New Jersey and encompasses part of the City of Camden and its environs. The streams included in this study are Pennsauken Creek, Pochack Creek, Cooper River, Newton Creek, Big Timber Creek, Little Timber Creek, and their respective tributaries. Those streams drain portions of Camden, Burlington and Gloucester Counties, and have a combined drainage area of approximately 150 square miles. The study area is shown on plates 1 and 2 of this report. A study of the water resource problems along North Branch Newton Creek was reported on in a detailed project report prepared by the District Engineer in January 1967. That stream has, therefore, been excluded from this study.

6. STREAM CHARACTERISTICS. In their tidal reaches the streams included in the study area are characterized by sluggish flows, ill-defined channels, broad marshy tidal flats and an abundance of aquatic plants. Above their tidal reaches those streams and their tributaries feature meandering courses, narrow flood plains and easily defined channels, and exhibit swifter flows that are modified to an appreciable extent by numerous dams and encroachments on the streams. Those dams and encroachments were built by individuals and various agencies over the years for flood control, recreational, commercial and industrial purposes.

7. LAND USE AND DEVELOPMENT. The study area is located in the heart of the developing east coast megalopolis, an area that is becoming increasingly urbanized as land is developed rapidly by residential and business expansion. Trends established through the study of the economic history of the area indicate that Camden County will continue to be the hub of all commercial and industrial enterprises undertaken in the southern New Jersey area.

8. The report 1/ on a nationwide economic base study undertaken for the Water Resources Council presents the projected population for the Philadelphia Water Resource Planning Areas for the year 1980 as 7,152,600. That represents an increase, for the period 1960-1980 of 28 percent or an estimated growth rate on a compound rate basis, for that 20-year period, of 1.25 percent annually. The Camden County streams study area lies within the Philadelphia Water Resource Planning Area and its population growth rate is expected to closely approximate that estimated for the planning area.

9. Early industrial development in Camden County took place within that part of the county which lies along Delaware River and is close to Philadelphia. County land use figures show that approximately 56 percent of the total industry of Camden County is contained within a three-mile radius of downtown Camden. Manufacturing employment has decreased in the older areas in recent years while employment opportunities in the outlying sections has increased. That trend is expected to continue and future industrial activities in Camden County are expected to develop almost entirely in the outlying areas.

10. Commercial development in Camden County is concentrated in the established business centers of the older residential areas and along the principal highways in the county. This latter development has, for the most part, been of the "strip" variety, strung out along the highways, often less than a block in depth and frequently interspersed with other land uses. There are, however, increasing trends toward the grouping of varied commercial activities in centralized areas (shopping centers) in outlying residential sections.

11. In 1961 a report 2/ was made by the Camden County Planning Board presenting an analysis of land use characteristics in each municipality of that county. Each municipality was placed into one of four planning districts depending on its average gross

1/ "North Atlantic Regional Water Resources Study, Appendix B, Economic Base (Final Draft)", Office of Business Economics U.S. Department of Commerce and the Economic Research Service, U.S. Department of Agriculture.

2/ "Report on Land Use, Camden County, N.J.", Camden County Planning Board, June 1961.

density of population with considerations given to the location of each municipality within Camden County. Those planning districts are shown on plate 2 as Districts I, II, III and IV. The study area encompasses portions of Districts I, II and III. The available land use figures for Camden County were reviewed during the course of this study and were updated to reflect recent developments. A distribution of land usage for the study area as well as the four planning districts is shown in table 1.

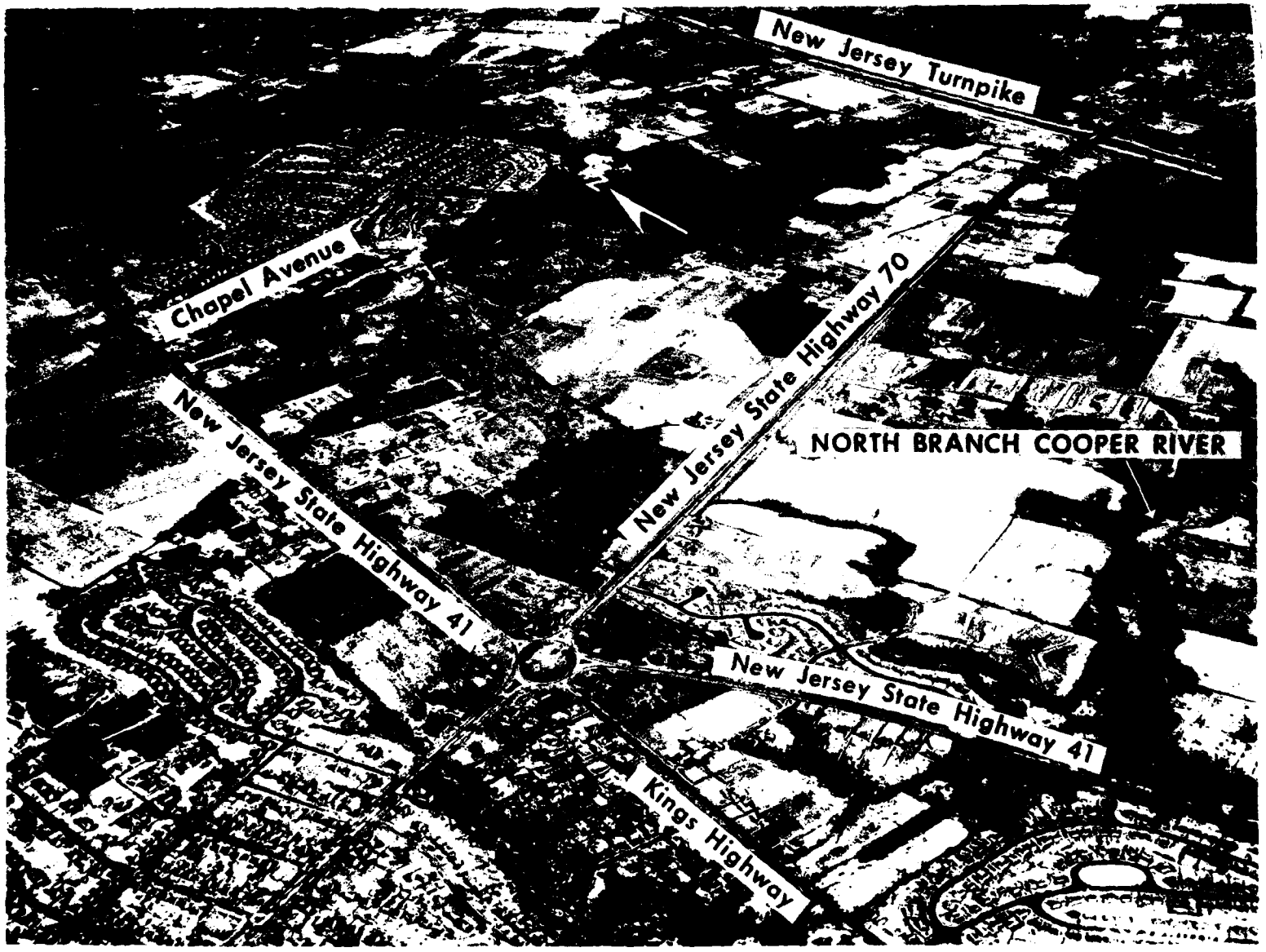
12. All suitable lands in the area designated as District I have been developed almost to the saturation point for residential, commercial and industrial purposes. The undeveloped lands in District I are low lying areas along Delaware River and Cooper River. Those lands are considered to be marginal lands as far as present development is concerned and will continue to be such as long as more desirable sites can be found elsewhere in the county. Vacant lands in District II are becoming rapidly saturated with residential, commercial and industrial developments. Presently almost all land available for development (agricultural and undeveloped) in District II lies in the southeast portion of Cherry Hill Township near the border with District III. Based on recent trends, additional residential, commercial and industrial developments within the study area would be located in Districts II and III. Photographs 1 and 2 offer a comparison of the change in land use and development typical of the study area in recent years in Districts II and III.

TABLE 1

CAMDEN COUNTY LAND USE

Area	Square Miles	Use of Land (Percent) Resi-dential	Commer-cial	Indus-trial	Agricul-tural	Public & Semi-Public	Undevel-oped	Water
Study area*	118.2	28	6	9	15	6	34	2
District I	32.9	49	9	12	1	8	15	6
District II	38.4	22	8	16	17	7	28	2
District III	57.9	17	1	1	21	5	54	1
District IV	96.1	2	0.4	0.5	25	1	71	0.1

* Data for that portion of the study area in Camden County only. Includes Districts I, II and a portion of District III. See plate 2.



PHOTOGRAPH 1. Aerial view of portion of study area in vicinity of traffic circle at junction of New Jersey State Highways 41 and 70. (December 1955.)

PHOTOGRAPH 2. Same area as shown in photograph 1. (February 1968.)
Note development of area since date of photograph 1.

13. WATER SUPPLY. In November 1961, the Camden County Planning Board published a report 3/ which inventoried the county's water resources and emphasized both present and future water supply needs. The major findings presented in that report are as follows.

a. Sources of present supply. The major portion of the water used in Camden County comes from the Raritan-Magothy, the Englishtown, the Mt. Laurel and Wenonah, and the Kirkwood-Cohansey aquifers. Estimated yields from the various aquifers are given in table 2.

TABLE 2
ESTIMATED POTENTIAL YIELD OF
MAJOR WATER BEARING FORMATIONS IN CAMDEN COUNTY

Aquifer	Recharge Capacity in Gals. per Sq.Mi.	Outcrop Area Sq.Mi.	Use Area Sq.Mi.	Est.Cap. per Day per Sq.Mi. (Gallons)	Estimated Yield in M.G.D. a/
Raritan-Magothy	1,000,000	17.0	116	260,000	30
Englishtown	600,000	7.5	50	100,000	5
Mt.Laurel & Wenonah	600,000	19.0	60	200,000	12
Kirkwood & Cohansey b/	1,000,000	144.0	113	1,000,000	113
				Estimated Potential Total Yield	160 MGD

a/ MGD = million gallons per day.

b/ The Kirkwood is included with the Cohansey since it is not considered to be an aquifer until tapped by wells far enough down dip to have sufficient thickness for domestic supplies.

b. Present demand. The present water usage in Camden County is comprised of consumption for agricultural, industrial, and domestic purposes. All of the water used is obtained from underground sources within the county except for about 3.2 million gallons per day which is drawn directly from Delaware River for industrial purposes. The total water demand as of 1960-61 is shown in table 3.

3/ "Report on Water Resources - Camden County, N. J. ", Camden County Planning Board, November 1961.

TABLE 3

TOTAL WATER DEMAND - CAMDEN COUNTY
1960 - 1961

Usage	Million Gallons per Year	Million Gallons per Day
Agricultural	708	2
Industrial	9,144	25
Domestic & Commercial	7,319	20
Total Consumption	17,171	47

c. Future demand. An estimated per-capita consumption for 1980 of 137 gallons per day was adopted by the Camden County Planning Board for the purpose of projecting future demands. Its projection was based on an analysis of estimates made by the New Jersey Division of Water Policy and Supply and estimates contained in the report on a survey of New Jersey water resources development. 4/ Those estimates are shown in table 4. The estimate of future demand was reviewed during the course of this study and was found to be reasonable.

TABLE 4

COMPARATIVE ESTIMATE OF FUTURE WATER DEMANDS
CAMDEN COUNTY

	N. J. Division of Water Policy & Supply			TAMS Report 4/		
Year	Population thousands	Million Gal/Day	Gals. per Capita/Day	Population thousands	Million Gal/Day	Gals. per Capita/Day
1920	190.0	20.1	105	190	17	90
1930	252.0	27.9	110	252	27	107
1940	256.0	26.3	103	256	25	98
1950	301.0	36.0	120	301	33	110
1960	375.5	47.0	125	350	40	114
1970	447.3	58.0	130	400	53	132
1980	511.2	68.0	133	450	63	140
1990	560.3	76.0	135	480	71	148
2000	587.2	80.0	136	510	76	150

4/ "Survey of New Jersey Water Resources Development", Tippetts-Abbott-McCarthy-Stratton, Engineers and Architects, New York, 1955.

14. SEWAGE DISPOSAL. Parts of the study area, particularly in the rural areas of the western and southwestern portions, depend on residential type units such as septic tanks for disposal of domestic sewage. As residential areas increase and become more urbanized, developers and municipalities are installing sewer lines and constructing sewage treatment plants. Those plants are being built adjacent to the streams that flow through the study area and the effluent from those plants is discharged into the streams. Effluent quality requirements are included in the water quality standards adopted by the Delaware River Basin Commission. 5/ Similar standards have been adopted by the State of New Jersey with full compliance required by 1970.

15. FISH AND WILDLIFE. The streams considered in this study are located in an area of high human density with extensive residential and industrial development. However, there are several marsh areas along the upper reaches of Cooper River and Big Timber Creek that provide habitat of value to waterfowl. Anticipated developments along those streams would reduce the value of any wildlife resources in the study area. The fishery resources in Camden County streams are presently not of significant value due to pollution and prevailing low flows.

16. RECREATION. Recreational opportunities present in Camden County are both extensive and varied. The Camden County park system has approximately 4,000 acres consisting of 2,000 acres of water and 2,000 acres of park land. The park area along Cooper River provides a yacht club with a sailing course. The lands are used for playgrounds, ballfields, picnic areas and swimming pools. In addition, there are also approximately 950 acres of municipal parks and school district playgrounds. Available data indicate that another 2,100 acres were used in 1962 for private recreation facilities consisting of small recreational parks, lakes, golf courses and country clubs.

17. Studies were made by the Camden County Planning Board to evaluate the status of existing parks and recreational facilities in the county. The report 6/ on those studies recommended that a minimum of 4,700 additional acres of land be acquired or improved by the county and municipalities to provide for parks and recreational open spaces by the year 1980.

5/ The Delaware River Basin Commission was created by agreement in 1961 between the states of Delaware, New Jersey and New York and the Commonwealth of Pennsylvania, and the United States of America with the power and duty to develop and effectuate plans, policies and projects relating to the water resources of the Delaware River Basin.

6/ "Conservation and Recreation in Camden County", Camden County Planning Board, December 1963.

18. PORT FACILITIES. Camden County is served by the facilities of the Port of Philadelphia. 7/ Based on the total tonnage handled, the port ranks among the world's busiest. The port is the second largest in the United States, the largest fresh water port in the world, and the largest importing port, based on tonnage volume, in the United States. The Port of Philadelphia handles well over 100-million tons of cargo annually. The port area of Camden, including Camden and Gloucester cities, extends from Big Timber Creek on the south to and including the lower reaches of Cooper River and Petty Island on the north. The Camden Marine Terminals, owned and operated by the South Jersey Port Corporation, offer modern warehousing as well as facilities for shipment by rail, highway and water. It has 226,000 square feet of inclosed storage space, 23 acres of open storage space and railroad service by the Penn Central Company and the Pennsylvania-Reading Seashore Lines.

PRIOR REPORTS AND IMPROVEMENTS

19. PRIOR REPORTS. There are nine recent reports which are pertinent to the problems of the area under study. Those reports are listed in table 5.

20. EXISTING CORPS OF ENGINEERS' PROJECTS. There are Corps of Engineers' projects for navigation on Cooper River and Big Timber Creek. There is also a Corps of Engineers' project for flood control on North Branch of Newton Creek. Data on those projects is given in table 6.

21. IMPROVEMENTS BY OTHER FEDERAL AGENCIES. No improvements for flood control or other water resource developments have been made by other Federal agencies on any of the streams in the study area. The Soil Conservation Service, Department of Agriculture, investigated a flood control proposal on Newton Creek late in 1962. Because of the urban nature of the area, it recommended to local interests that the Corps of Engineers be contacted. The Soil Conservation Service does not have any interest in that watershed at the present time, nor does it foresee any possible future interest.

22. IMPROVEMENTS BY NON-FEDERAL AGENCIES. Local agencies, individual property owners, private clubs and real estate developers have made improvements for flood control and other water resource developments on various streams in the study area. Those improvements were made largely on a piece-meal basis as the need arose and funds became available and were not coordinated with water resource development needs of the entire area of the watershed in which they were made.

7/ Includes ports of Philadelphia, Chester and Marcus Hook, Pennsylvania; Camden, Gloucester, Paulsboro and Trenton, New Jersey, and Wilmington, Delaware.

TABLE 5
PRIOR REPORTS-CAMDEN COUNTY STREAMS STUDY AREA

Nature of Study and Stream	Date of Report	Recommendation	Recommendation of the Chief of Engineers	Congressional Documents: House or Senate	Number	Congress	Session	Remarks
Navigation								
Big Timber Creek	Jun 9, 1927	Favorable	Favorable	House	217	70	1	Provide channel, including two cutoffs, from Delaware R. upstream approximately 5-½ miles to Marter's sand plan
	May 15, 1933	Favorable	Favorable	House	15	73	1	Recommends modification of existing project to extend channel from Marter's sand plant upstream approximately 1-3/4 miles to Clements Bridge.
Flooding								
Chandlers Run	Jul 23, 1963	Unfavorable						Reconnaissance report found remedial actions to be matters of local responsibility.
Delaware R., N.Y., N.J., and Pa.	Aug 6, 1932	Unfavorable	Unfavorable	House	179	73	2	Found that no project for flood control alone could be economically justified at that time.
Delaware R. Basin, N.Y., N.J., Pa., and Del.	Apr 2, 1962	Favorable	Favorable	House	522	87	2	As part of study, survey made of damages in Camden, Burlington and Gloucester Counties, N.J. from flood of 18-20 Aug 55. Report made no recommendations for flood control improvements along streams in those counties.
Delaware R. and Bay, Pa., N.J., and Del.	Aug 17, 1964	Unfavorable	Unfavorable	House	348	88	2	Report contains discussion of effects tidal storms have had on Camden, N.J., area. Report concludes tidal flood protection works not economically justified at that time.
North Branch Newton Creek	Jan 16, 1967	Favorable	Favorable					Detailed project report submitted under authority of Section 205 of Flood Control Act of 1948, as amended. Recommended construction of local flood protective works.
Flood Plain Information								
Big Timber Creek	Mar 1969							Study of past floods and possible future floods on main stem and South Branch upstream for 9.3 miles and North Branch upstream from confluence with South Branch for 5.8 miles. 2 volumes.
Little Timber Creek	Mar 1969							Study of past floods and possible future floods on Little Timber Creek upstream from confluence with Big Timber Creek for 3.5 miles.

TABLE 6
EXISTING CORPS OF ENGINEERS' PROJECTS
CAMDEN COUNTY STREAMS STUDY AREA

STREAM	TYPE OF PROJECT	YEAR ADOPTED	YEAR COMPLETED	DESCRIPTION	REMARKS
Big Timber Creek	Navigation	1930 modified 1935	1941	See Table 5.	Dredging last accomplished fiscal year 1962. Controlling depth at local mean low water: Apr 1967, 9.5 ft. Delware R. Channel to mouth, 9.8 ft. to U. S. 130, 5.0 ft. to Marter's sand plant; May 1967, 3.1 ft. to upper end of project.
Cooper River	Navigation	1896	1920	Channel 12 ft. deep and 70 ft. wide, Delaware R. upstream about 1-3/4 miles to Monsanto chemical plant.	Maintenance dredging last accomplished fiscal year 1962. Controlling depth at local mean low water: May 1971, 6.0 ft. Delaware R. to Penn Central RR bridge, 6.8 ft. to upper end of project.
North Branch Newton Creek	Flood Control	1967	-	See Table 5.	Project will be advertised for construction when local interests comply fully with items of local cooperation set forth in detailed project report.

23. The Delaware River Port Authority is presently constructing the Delair Bridge, a major highway bridge crossing the Delaware River between Philadelphia and a point near the mouth of Pochack Creek. Included in the plans for the New Jersey approach to this highway bridge are:

a. acquisition of properties that have been subject to flooding from Pochack Creek.

b. realignment of Pochack Creek with adequate provisions for new road and railroad culverts, and tidal protection.

The construction of that bridge will eliminate the recurrent flood problem in the lower reach of Pochack Creek in Pennsuaken Township.

PROBLEMS UNDER INVESTIGATION

24. WATER POLLUTION. Low base streamflow combined with the discharge of effluent from industrial facilities and sewage treatment plants into the streams that flow through the study area have caused serious water quality problems. There are now approximately 50 sewage treatment plants in the study area and a great deal of the stream flow is comprised of effluent from those plants. Several of the streams in the study area are polluted to the extent that, during times of low flow, treatment plant effluent represents 80 to 90 percent of the stream flow. Stream pollution has adverse effects on the fish and wildlife resources in the county, limits water associated recreational potential of the streams and has the potential for infiltrating into the aquifers that are the main source of the water supply of Camden County. In addition, the increase of nutrients in the stream, brought about by the sewage treatment plant effluent, enhances aquatic plant growth in sluggish backwater areas along the main channels which, in turn, has a secondary effect of increasing the insect population in those areas.

25. NAVIGATION. The only known navigation problem along any of the streams in the study area involves commercial shipping on Big Timber Creek. The problem arises from the usage of that stream by vessels of draft greater than existing project channel depth.

26. FLOODING. The study area has suffered frequently from floods that have been caused by various types of storm conditions including tropical hurricanes; extra-tropical storms originating off the Carolinas; storms originating in the Gulf of Mexico; and continental storms originating over land areas of the United States, Canada and polar regions. The most severe storms in the Delaware River Basin occur when a hurricane joins an extra-tropical storm and the two storms travel together exhibiting a characteristic isohyetal storm pattern having two major storm centers. However, smaller, more intense, localized storms have caused considerable flooding in portions of the study area.

27. Not every flood producing storm has caused flooding along all streams in the study area. Nor have those exceptional storms that caused flooding throughout the entire area resulted in the maximum known floods along each stream. Data on many floods indicating time of occurrence, flood heights and associated damages is either limited or non-existent. It is only for the major floods of recent years that reports have been made to the Corps of Engineers and flood damages reliably documented. Selected flood events that are typical of those experienced along the streams in the study area are listed in table 7.

28. To a great extent, the hazard of floods is being disregarded in the development of commercial and industrial centers in the tidal reaches of streams and in the residential development of former rural areas in the upstream reaches. Flooding along the streams in the study area is generated by two different causes; namely, fluvial runoff in non-tidal reaches and high tide stages in tidal reaches. A general description of the flood problems associated with those reaches is given in the following paragraphs.

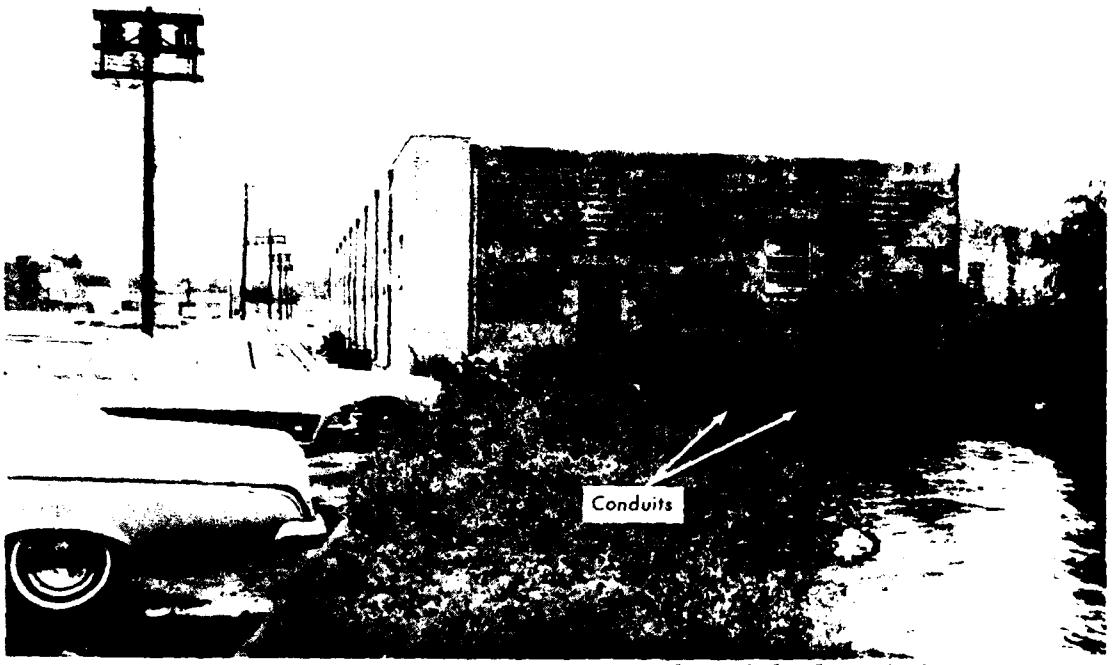
a. Non-tidal reaches.

(1) Scattered residential, commercial, industrial and municipal facilities along the upstream reaches of the streams in the study area are subject to occasional flooding from overbank flow. At times of flood flows, traffic is also disrupted. The flooding along the non-tidal reaches of the stream is primarily a matter of inadequate means for disposal of storm runoff. Improvement and maintenance of the drainage systems has not kept pace with the rapid change in the nature of development from rural to urban. Photographs 1 and 2 illustrate the rapid change from rural countryside to an urban area. The meandering course followed by the streams in their non-tidal reaches contain many sharp bends that also contribute to the flood problems. In some areas the stream banks are too low to contain any but low flow stages. In other areas the channel capacities have been reduced by encroachments for residential, commercial and industrial developments. In addition, the hydraulic capacities of streams have been further reduced by the silting of culverts and the accumulation of debris such as down timber and discarded man-made material. Those conditions are shown in photographs 3, 4 and 5. During flood flows, debris collects at many bridges and culverts on the streams further increasing the flood stages. The magnitude of recurrent flood damage along several streams has been increased as a result of the lack of zoning ordinances pertaining to developments within the flood plains.

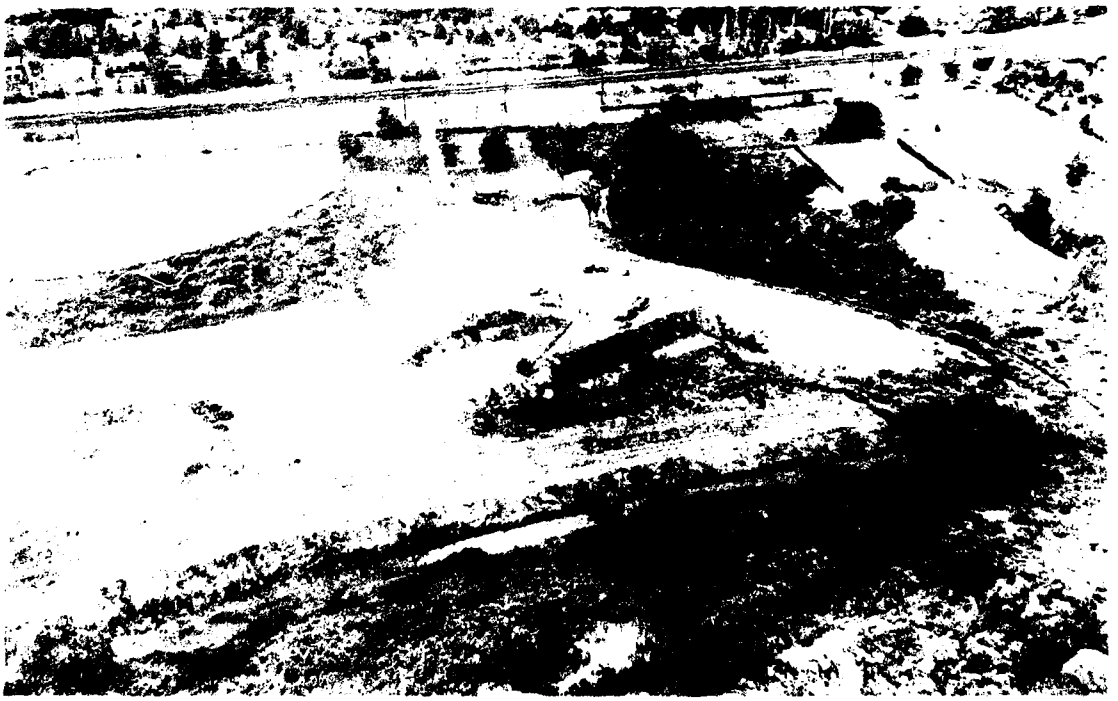
(2) Private interests have created numerous impoundments along the streams in connection with real estate developments and for recreational and industrial purposes. Two of the impoundments are shown in photographs 6 and 7. During the storm of 1 September 1940, many of the dams at those lakes failed with consequent devastating

TABLE 7
SELECTED RECORDED FLOODS-CAMDEN COUNTY STREAMS STUDY AREA

Date of Storm	Nature of Storm	Area Flooded	Description	Remarks
1 Sep 40	Hurricane	Upper reaches of streams	Storm occurred over narrow belt that extended northeastward over study area. Storm produced about 8 inches of rain over the study area with 80 to 85% falling during first 7 hours.	Flood was one of most damaging experienced in southern New Jersey. Storm's effects increased due to soil of area having been saturated by continuous rainfall of about 3.5 inches during 5 days prior to 1 Sep.
11-14 Aug 55	Hurricane "Connie"	Low-lying areas along all streams	Combination of 5.5 inches rain, high tide and winds caused tidal surges that flooded low-lying lands.	Delaware R. reached near record elevation of 8.0 feet sld on 13 Aug.
16-19 Aug 55	Hurricane "Diane"	Non-tidal reaches all streams	Runoff from 3 inches rain caused floods that occurred with remarkable rapidity.	Delaware R. reached maximum elevation of 7.8 feet sld on 20 Aug. Rainfall from "Connie" had left ground saturated, streams were at relatively high stages and conditions conducive to high runoff when "Diane" occurred. Maximum known flood in many sections of Delaware R. Basin but limited flooding in study area.
23-24 Jun 62	Thunder-storm	Northcentral Camden County	Short duration, high intensity thunderstorms. Total rainfall 23 Jun, 1.01 inches during 3-hour period. Total rainfall 24 Jun, 2.61 inches during 3-hour period with 2.07 inches in 1-hour period.	Area highly urbanized. High runoff associated with storm of 24 June due to saturated conditions from rainfall of preceding day.
27-28 Aug 62	Thunder-storm	Northcentral Camden County	Short duration, high intensity thunderstorm with total rainfall 3.65 inches in 8 hours. 3.55 inches fell in first 6 hours.	Area highly urbanized and runoff high.
9-10 Aug 67	Thunder-storm	Southwestern Camden County	Data from nearby station indicated that about 5 inches of rain fell in study area. Rain started late at night on 9 Aug and continued through morning of 10 Aug.	Storm followed intense rainfall of 3-4 Aug.

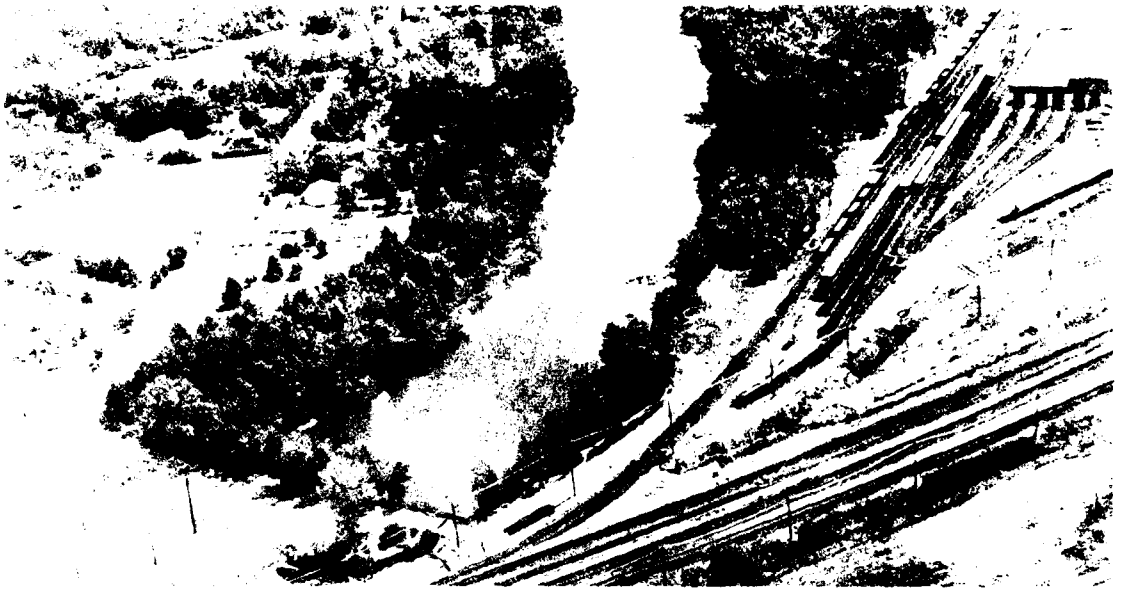


PHOTOGRAPH 3. Channel capacity reduced by industrial plant built over stream. Photograph shows upstream end of conduits carrying Pochack Creek under building. (June 1968.)

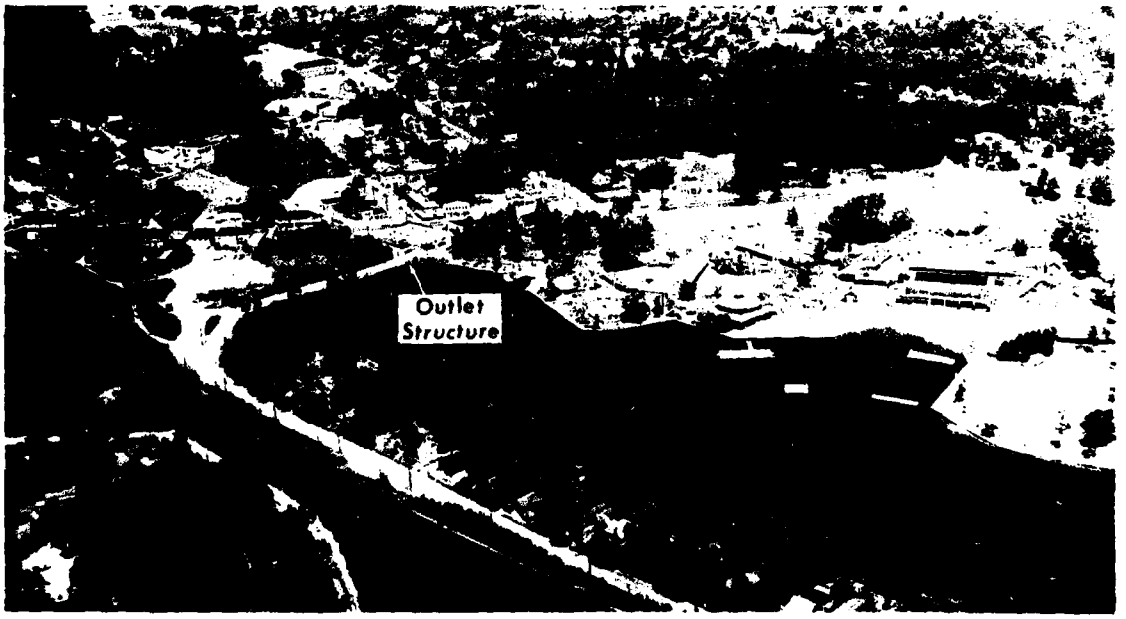


PHOTOGRAPH 4. Channel capacity reduced by landfill operation along a portion of non-tidal reach of Cooper River. (August 1968.)

PHOTOGRAPH 5. Channel capacity reduced by silting of streambed and accumulation of debris at culvert. Condition illustrated is typical of streams in study area.



PHOTOGRAPH 6. Kirkwood Lake on Cooper River created by private interests for real estate development. Spillway and conduit carrying stream under highway shown in lower center of photograph. Gated outlet works inoperable. (August 1968.)



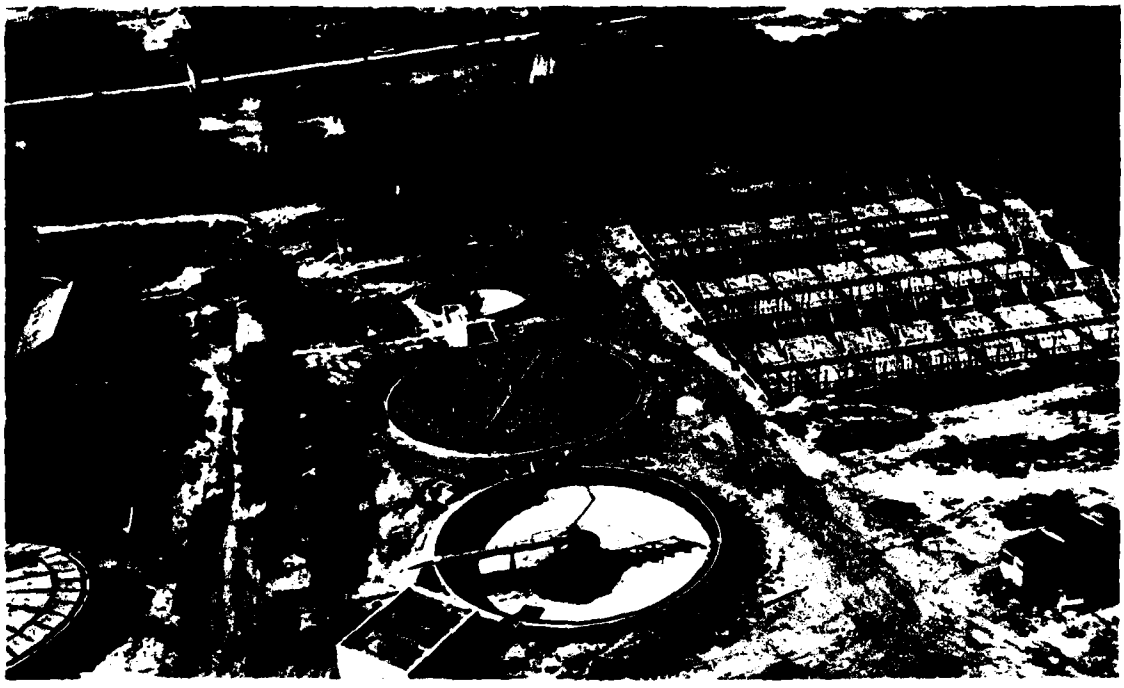
PHOTOGRAPH 7. Clementon Lake on North Branch of Big Timber Creek created by private interests originally for operation of mill. Lake now used for recreation. Gates on outlet structure are maintained in operable condition. Lake surface approximately two feet below immediate surrounding area. Town downstream of outlet structure lies at elevation below lake surface. (August 1968.)

damages from the resultant surges of streamflow. Although many of the dams have since been improved, many are equipped with gated outlet structures that are inadequate in size. Maintenance of the dams and the outlet controls has also been inadequate. As a result, the controls do not function properly, if at all. Most of the lakes have little capacity for storage of flood flows. Also, there is no coordinated effort on the part of local officials or agencies to operate the lakes effectively for flood control purposes. The limited storage capacity, inoperable outlet controls and lack of a coordinated flood control procedure at times of heavy rainfall, constitute a potential for severe flood damage at communities downstream of the lakes.

b. Tidal reaches. Residential, commercial, industrial and municipal facilities located along the tidal reaches of the streams in the study area have experienced extensive flooding as a result of overbank flow. Flood flows have also disrupted rail and highway traffic for varying periods of time. Flood problems along the tidal reaches of the streams result from abnormally high tides and from the combination of high tides and a high rate of surface runoff. High tidal stages reduce the effectiveness of many storm drains causing ponding in some inland areas. In most cases the natural stream banks are too low to contain any but normal high tide stages. Channel capacities in tidal reaches have been reduced by encroachments for commercial and industrial developments as well as sanitary land fill operations. Photographs 8, 9, 10 and 11 illustrate typical conditions that contribute to flood damages along the tidal reaches of the streams.

29. FLOOD DAMAGES. Flood events experienced along the streams in the study area have caused washouts at small dams, bridges and culverts; large areas have been inundated to depths of as much as 2-1/2 feet; sewage treatment plants, water supply pumping stations, fire stations, post offices and other municipal facilities have been damaged, and rail movements and highway traffic has been disrupted. In addition, floods have washed out roads, destroyed crops, damaged electric, gas and telephone facilities, and inumdated houses, commercial establishments and recreational facilities. Data for the damage survey conducted by the Corps of Engineers following the storm of 16-19 August 1955 (table 7) was used in this study. The results of that survey, escalated to the July 1971 price level, are as follows. Physical damages to residential, commercial, industrial and public properties including highways, totaled $125,000; business losses were $37,000; and emergency costs were $32,100. Total damages amounted to $194,100.

30. A detailed damage survey along the streams in the study area was made during July and August 1964. That survey was made to evaluate all recurring tangible damages and to identify intangible damages caused by flooding. During the course of this study, supplemental surveys were made in response to reported localized flood problems along individual streams in the study area. Data collected during the surveys, where pertinent, was used to augment the 1964 damage survey.



PHOTOGRAPH 8. Encroachment on North Branch Pennsauken Creek flood plain for sewage treatment plant. (August 1968.)

PHOTOGRAPH 9. Channel capacity reduced by debris deposited by tide in Pochack Creek at Penn Central railroad tracks (looking upstream). Condition illustrated is typical of tidal reach of all streams in study area. (August 1968.)

PHOTOGRAPH 10. Commercial and industrial development along Cooper River. Development shown is typical of tidal reach of river. (August 1968.)

PHOTOGRAPH 11. Residential development in flood plain. Photograph shows portion of tidal reach of Big Timber Creek. (August 1968.)

31. The data collected during the 1964 and supplemental flood damage surveys was analyzed to locate and define the areas that are subject to recurrent flooding. Those surveys also identified the storm that caused the most damage along each of the streams in the study area. Summaries of estimated flood damages at the present level of development, for an occurrence of a flood similar in magnitude to the most damaging flood experienced along each stream under study are presented in tables 8, 9, 10, 11, 12 and 13.

PROPOSED SOLUTIONS AND PROJECT FORMULATION

32. IMPROVEMENTS DESIRED. In order to obtain the views of all interested parties concerning the need, character, advisability and extent of flood control and other water resource improvements in the study area, a public hearing was held by the Philadelphia District Engineer on 30 March 1964 at Camden, New Jersey. The hearing was attended by some 70 representatives of the various Federal, State, county and municipal governments, commercial and industrial interests, and residents of the various localities involved. The primary concern expressed at the hearing was for improvements for flood control in the more developed areas of the county. Improvements suggested at the hearing included such items as the removal of silt and debris from streams, modification of the existing dam on Cooper River, construction of tidal dams on several of the streams, improvement of stream channels including deepening and widening, dredging of the channel in back of Petty Island and control of developments on land adjacent to the streams.

33. At the public hearing, Mr. John D. Tomaselli, Planning Director, Camden County Planning Board presented observations of the Board pertaining to the possible solutions of the flood problems. The Planning Board developed its observations in response to a request of the Board of Chosen Freeholders of Camden County that the Planning Board investigate the problem of recurrent flooding in Camden County and see what corrective measures might be necessary. The Planning Board suggested that detailed investigations be made into the feasibility of the construction of tidal dams at the mouths of Cooper River and Newton Creek. It also suggested that tidal flow in Cooper River be restricted by filling in the channel in back of Petty Island to the mean low water mark. It was also suggested that the filling might be combined with a dam from north Camden to Petty Island thereby forcing Cooper River to flow north through the channel, hopefully reducing the tidal effect upstream.

34. Mr. William W. Messenger, then Superintendent of Parks, Camden County Park Commission, who also appeared at the public hearing, called attention to the flooding problems in county park lands along Cooper River and Newton Creek. He stated that the problems were brought about from high tide stages in those streams and in Delaware River. Mr. Messenger suggested that in order to control Cooper River adequately, it would be necessary to either modify the existing tidal dam on Cooper River or construct a new dam at its mouth.

TABLE 8
SUMMARY OF ESTIMATED FLOOD DAMAGES
FOR MOST DAMAGING FLOOD EVENT EXPERIENCED
PRESENT LEVEL OF DEVELOPMENT
PENNSAUKEN CREEK
(July 1971 price level)

DAMAGE AREA	DATE OF REFERENCE FLOOD	DAMAGES	REMARKS
NORTH BRANCH			
Moorestown Twp.	1 Sep 1940	$13,900	Fluvial flooding of homes, commercial property and waterwell pumping station built around lake east of State Highway 38.
Moorestown Twp. & Maple Shade Twp.	1 Sep 1940	589,000	Fluvial flooding of homes and commercial properties along right bank (Moorestown Twp.) and commercial and municipal properties along left bank (Maple Shade Twp.)
SOUTH BRANCH			
Evesham Twp. & Cherry Hill Twp.	1 Sep 1940	7,900	Fluvial flooding of homes in scattered areas of headwaters.
Cherry Hill Twp.	1 Sep 1940	4,600	Fluvial flooding of sewage disposal plant on left bank.
Pennsauken Twp.	1 Sep 1940	1,600	Fluvial flooding of waterwell pumping station on left bank.
MAIN STEM			
Cinnaminson Twp.	13 Aug 1955	22,500	Tidal flooding of residential development on right bank immediately downstream of U. S. Highway 130.
Palmyra Boro.	13 Aug 1955	17,100	Tidal flooding of small residential area on right bank.

TABLE 9
SUMMARY OF ESTIMATED FLOOD DAMAGES
FOR MOST DAMAGING FLOOD EVENT EXPERIENCED
PRESENT LEVEL OF DEVELOPMENT
POCHACK CREEK
(July 1971 price level)

DAMAGE AREA	DATE OF REFERENCE FLOOD	DAMAGES	REMARKS
Pennsauken Twp. a/ (Industrial Park)	23-24 Jun 1962	$7,500	Fluvial flooding of industrial and commercial development upstream of U. S. Highway 130. One building built on top of Creek.
Pennsauken Twp. b/	23-24 Jun 1962	96,800	Fluvial flooding of water treatment plant, residential development and commercial properties.

a/ Approximately 1.6 miles upstream of mouth of Pochack Creek.

b/ Approximately 0.6 miles upstream of mouth of Pochack Creek.

TABLE 10
SUMMARY OF ESTIMATED FLOOD DAMAGES
FOR MOST DAMAGING FLOOD EVENT EXPERIENCED
PRESENT LEVEL OF DEVELOPMENT
COOPER RIVER
(July 1971 price level)

DAMAGE AREA	DATE OF REFERENCE FLOOD	DAMAGES	REMARKS
MAIN STEM			
Somerdale Boro.	1 Sep 1940	$ 42,400	Fluvial flooding of homes and sewage treatment plant.
Haddonfield Boro.	1 Sep 1940	4,200	Fluvial flooding of water well pumping station.
Cherry Hill Twp. a/	1 Sep 1940	26,600	Fluvial flooding of homes and commercial establishments.
Cherry Hill Twp. b/	13 Aug 1955	3,400	Fluvial runoff ponded by high tide causing damage to miniature golf course.
Collingswood Boro.-Haddon Twp.	13 Aug 1955	19,400	Fluvial runoff ponded by high tide causing damage to scattered areas (homes, sewage treatment plant, commercial developments).
City of Camden (right bank of river)	13 Aug 1955	437,000	Tidal flooding of homes and commercial and industrial developments.
CHANDLERS RUN			
Pennsauken Twp.	23-24 Jun 1962	50,800	Tidal flooding of homes and commercial and industrial developments.

a/ Approximately 8.5 miles upstream of mouth of Cooper River.
b/ Approximately 5 miles upstream of mouth of Cooper River.

TABLE 11
SUMMARY OF ESTIMATED FLOOD DAMAGES
FOR MOST DAMAGING FLOOD EVENT EXPERIENCED
PRESENT LEVEL OF DEVELOPMENT
NEWTON CREEK
(July 1971 price level)

DAMAGE AREA	DATE OF REFERENCE FLOOD	DAMAGES	REMARKS
MAIN STEM			
Haddonfield Boro.-Haddon Twp.	27-28 Aug 1962	$ 52,900	Fluvial flooding of homes.
Haddon Twp. a/	27-28 Aug 1962	6,900	Fluvial flooding of homes.
Haddon Twp. b/	27-28 Aug 1962	12,200	Fluvial flooding of homes.
Collingswood Boro.	13 Aug 1955	11,900	Fluvial runoff ponded by high tide causing damage to miniature golf course at U. S. Highway 30.
Haddon Twp.-Audubon Park Boro.	27-28 Aug 1962	1,700	Fluvial runoff ponded by high tide causing damage to several commercial developments.
City of Camden - Gloucester City	13 Aug 1955	30,900	Tidal flooding of homes and commercial developments.
SOUTH BRANCH			
Audubon Boro.	27-28 Aug 1962	75,300	Fluvial flooding of homes.
Audubon Boro.-Mt. Ephraim Boro.	27-28 Aug 1962	5,000	Fluvial flooding of sewage treatment plant in Audubon Boro.

TABLE 11 (Cont'd)
SUMMARY OF ESTIMATED FLOOD DAMAGES
FOR MOST DAMAGING FLOOD EVENT EXPERIENCED
PRESENT LEVEL OF DEVELOPMENT
NEWTON CREEK
(July 1971 price level)

DAMAGE AREA	DATE OF REFERENCE FLOOD	DAMAGES	REMARKS
SOUTH BRANCH (Cont'd)			
Haddon Twp.	13 Aug 1955	$3,000	Tidal flooding of homes.
Gloucester City	13 Aug 1955	38,700	Tidal flooding of water works, homes and commercial property.
PETER CREEK			
Audubon Boro.	27 - 28 Aug 1962	51,400	Fluvial flooding of homes and commercial property.

a/ Approximately 5.5 miles upstream of mouth of Newton Creek.
b/ Approximately 5.2 miles upstream of mouth of Newton Creek.

TABLE 12
SUMMARY OF ESTIMATED FLOOD DAMAGES
FOR MOST DAMAGING FLOOD EVENT EXPERIENCED
PRESENT LEVEL OF DEVELOPMENT
LITTLE TIMBER CREEK
(July 1971 price level)

DAMAGE AREA	DATE OF REFERENCE FLOOD	DAMAGES	REMARKS
Barrington Boro. a/	27 - 28 Aug 1962	$173,000	Fluvial flooding of single-home dwellings in headwater area of stream. Flooding occurs at local storm drainage inlets.
Barrington Boro. b/	27 - 28 Aug 1962	4,200	Fluvial flooding of homes along unnamed tributary in headwaters area.
Haddon Heights Boro.	27 - 28 Aug 1962	7,400	Fluvial flooding of swim club and undeveloped lands, all on right bank of creek.
Mt. Ephraim Boro. c/	27 - 28 Aug 1962	2,800	Fluvial flooding of residential area on right bank of creek.
Mt. Ephraim Boro. d/	13 Aug 1955	5,300	Tidal flooding of residential areas on right bank of creek.
Gloucester City	13 Aug 1955	800	Tidal flooding of sewage treatment plant on right bank of creek.
Brooklawn Boro.	13 Aug 1955	800	Tidal flooding of sewage treatment plant on left bank of creek.

a/ North of Interstate Highway 295
b/ South of Interstate Highway 295
c/ Approximately 2.5 miles upstream of mouth of Little Timber Creek.
d/ Approximately 2.2 miles upstream of mouth of Little Timber Creek.

TABLE 13
SUMMARY OF ESTIMATED FLOOD DAMAGES
FOR MOST DAMAGING FLOOD EVENT EXPERIENCED
PRESENT LEVEL OF DEVELOPMENT
BIG TIMBER CREEK
(July 1971 price levels)

DAMAGE AREA	DATE OF REFERENCE FLOOD	DAMAGES	REMARKS
MAIN STEM			
Bellmawr Boro. a/	13 Aug 1955	$ 2,700	Tidal flooding of swim club with potential for flooding residential development and highways at slightly higher flood stage.
Bellmawr Boro. b/ & Brooklawn Boro.	13 Aug 1955	73,100	Tidal flooding of highways and commercial and residential development.
Westville Boro.	13 Aug 1955	128,000	Tidal flooding of highways and commercial and residential development.
NORTH BRANCH			
Somerdale Boro.	9-10 Aug 1967	Minor	Overbank flow flooded yards at rear of homes along Gravelly Run (a tributary to North Branch) and runoff backed-up through storm drains into basements of homes. Bank erosion also occurred.
BEAVER BROOK			
Barrington Boro. c/	27-28 Aug 1962	970	Fluvial flooding of a sewage disposal plant.
Runnemede Boro. d/	27-28 Aug 1962	280	Fluvial flooding of grounds and basement of home.
Bellmawr Boro. e/ & Runnemede Boro.	27-28 Aug 1962	6,000	Fluvial flooding of commercial area bordering State Highway 168.

a/ Approximately 3 miles upstream of mouth of Big Timber Creek.
b/ Approximately 1.5 miles upstream of mouth of Big Timber Creek.
c/ Approximately 3 miles upstream of mouth of Beaver Brook.
d/ Approximately 2.5 miles upstream of mouth of Beaver Brook.
e/ Approximately 2.1 miles upstream of mouth of Beaver Brook.

35. Representatives of the Camden Lime Company and the General Chemical Division of the Allied Chemical Corporation also spoke at the public hearing and expressed the view that, while seeing the need for flood control improvements, they were opposed to any designs that would restrict or prohibit navigation along Cooper River from Delaware River to their plants.

36. PROPOSED SOLUTIONS. The various plans evaluated for the solution of the water quality, navigation and flooding problems are discussed in the following paragraphs.

a. Water pollution. At the request of the Camden County Planning Board as expressed in a letter dated 7 May 1965, the Philadelphia District made studies in order to determine the feasibility of developing reservoir sites on South Branch Pennsauken Creek to increase base stream flow and upgrade water quality. Eleven potential sites along South Branch Pennsauken Creek were recommended by the Camden County Planning Board for possible storage development. Additional sites in the upper reaches of Big Timber Creek and Cooper River were also selected by the Philadelphia District for preliminary study. The locations of the possible impoundment sites are shown on plate 1. It was found that several of the potential sites either had been developed as residential areas or would not provide significant amounts of storage to augment low flows effectively. Nine sites in the study area were considered suitable as locations for reservoirs to augment base streamflow. Data on the probable regulated flows at those sites was furnished to the Federal Water Pollution Control Administration (now the Environmental Protection Agency) for review and recommendations. On 3 February 1967, that agency submitted to the Philadelphia District Engineer an unfavorable report on the proposed use of those sites for reservoirs to provide low flow augmentation for water quality improvement. The Federal Water Pollution Control Administration found that the combination of shallow water, sunlight and nutrients in sewage effluents would result in aquatic plant growth that would be aesthetically objectionable and would also render the reservoirs useless for recreation and flow regulation purposes.

b. Navigation. The nature and magnitude of the problems affecting commercial traffic on Big Timber Creek are such that any navigation improvement should be planned and constructed under the special continuing authority of Section 107 of the River and Harbor Act of 1960, as amended. Therefore, the navigation problems would be investigated in a separate study made under the authority of that act when a request is received from the appropriate authorities.

c. Flooding. Comprehensive planning for the solution of flood problems demands that all possible flood prevention or flood damage reduction measures be given consideration. Generally, flood damages may be prevented or reduced through structural measures, non-structural measures or combinations of both. Structural measures seek to lower flood stages or provide barriers against flood waters. Non-structural measures seek to reduce flood damages and damage potentials. The structural and non-structural measures that were evaluated during this study are described in detail in paragraph 39.

37. PROJECT FORMULATION. The primary need of the study area in the field of water resources is for protection against flooding. The following general concepts were used as basic criteria in formulating a plan of improvement for each stream within the study area. The improvements, and each segment and feature thereof, were selected and scaled to:

a. Provide a practicable and economic means of fulfilling an existing or prospective need.

b. Consider all determinate economic influences, tangible or intangible, beneficial or detrimental.

c. Provide for a maximum excess of tangible benefits over costs.

d. Give consideration to the views of local interests.

38. The types of improvements required to satisfy flood control needs were determined by an analysis of the causes of past flood events (hurricanes, thunderstorms, high tides), the topography of the study area, an examination of stream conditions that contribute to flood stages (encroachment on the flood plains, inadequate culverts, inadequate storm drainage systems, trash in the stream channel), a survey of the type of developments in the damage areas (residential, commercial, industrial), consideration of all economic influences (reduction of flood damages, possible increased land utilization, land enhancement) and increased security and welfare of residents of the study area. Those studies and examinations also were the basis for the determination of the Federal interest in providing improvements for flood control. After careful consideration of flood characteristics and frequencies, potential for development in the individual watersheds, the nature of the areas to be protected and regional economic factors, the improvements for flood control were scaled to provide protection against floods with a 100-year recurrence interval.

39. ALTERNATIVE FLOOD CONTROL PLANS. The damage areas along each stream were studied as separate integral components with a view to developing the over-all plan of flood control for the study area. Various alternative measures considered for flood control are discussed in the following subparagraphs.

a. Structural measures. The following structural measures were considered for use as protection against recurrent flooding.

(1) Flood control reservoirs. Potential sites for detention basins or flood control reservoirs were investigated. It was found that all potential sites with sufficient capacity to control flood flows effectively had already been developed for recreational purposes.

(2) Tidal barriers. Potential sites for location of tidal barriers were investigated. It was found that without costly pumping facilities, such sites could only provide sufficient pond area upstream of the barrier to store runoff effectively from storms of low intensity and relatively high frequency.

(3) Local protective works. Construction of earth levees, concrete flood walls or a combination of both was considered for the protection of the areas that are susceptible to recurrent flooding.

(4) Bridge and culvert modifications. Replacement of hydraulically inadequate bridges and culverts was considered for the solution of the flood problems. Bridge and culvert modifications were also included, wherever necessary, as part of local protective works plans evaluated for the protection of areas subject to recurrent flooding.

(5) Channel improvements. Structural measures that include concrete flumes, stream clearing and grading and embankment rectification were considered for the alleviation of the flood problems.

b. Non-structural measures. The following non-structural measures were considered for reduction of recurrent flood damages.

(1) Evacuation. In general, abandonment of the flood prone areas, relocation of the commercial and industrial facilities now situated in those areas and the resettlement of the inhabitants were considered impractical because of the undesirable economic impact on the interests that would be affected.

(2) Flood forecasting. A reliable, accurate and timely forecasting of possible flooding and flood water stages and a general awareness of the potential flood hazard and its effects would do much to reduce damages. A flood warning system that could be activated by local interests upon notification from the National Oceanic and Atmospheric Administration of the existence of a flood threat, would benefit homeowners and others by enabling them to activate emergency measures and standby flood proofing measures.

(3) Flood proofing program. A flood proofing program could be adopted by local interests and private individuals as a means of obtaining partial protection for existing structures. Flood proofing consists of those adjustments to structures and building contents which are designed or adopted primarily to reduce flood damages once the water reaches the structures. Flood proofing measures can be classified as permanent measures and standby measures. A brief description of each follows.

(a) Permanent flood proofing measures consist of the works which become an integral part of the structure and are aimed at the elimination of openings through which water can enter. Permanent measures would involve the waterproofing of building walls and floors, relocating machinery, electrical circuits and other utilities above flood levels,

sealing off unused and unnecessary doors, windows and other openings, constructing low walls around building entrances and windows to prevent overland flow from entering subsurface levels and installing gate valves or flap gates on utility pipe openings.

(b) Standby flood proofing measures consist of those works which are used only during floods because of the physical limitations of the structures to be protected. These measures can be used where it is necessary to maintain existing access points into structures or where windows and utility openings cannot be permanently closed. Such standby measures would include a plan of orderly removal of machines and merchandise, fitting doorways, display windows and other access points with removable bulkheads, and sandbagging window openings to prevent breaking and inflow of flood waters.

(4) Flood plain regulations. Enactment of realistic regulatory measures for management of the use of the flood plain would be applicable in those areas along the streams that are not too intensely developed and in undeveloped areas. The adoption of realistic regulatory measures governing construction on and occupancy of flood plains would minimize potential flood damages and future protection costs. Such measures could control the encroachment on stream channels by regulating the construction of flow restricting developments. Regulations governing the occupancy of flood plains would protect against loss of life from floods. Flood plain regulations would include land use planning, flood plain zoning, subdivision regulation, channel encroachment ordinances and building codes. All of those measures would emphasize the proper use of flood prone areas and developing them for purposes that are relatively undisturbed by temporary flooding. In a typical flood plain zoning ordinance, an area is designated as having a high potential for flooding and hence marked as a zone which would have special restrictions or regulations. Within this high risk zone only those land uses would be permitted which are not subject to significant damage by flood waters and would not restrict flood flow. That type of land use would include golf courses, park lands, parking facilities, open areas, small neighborhood playgrounds and other uses for the development of the water-oriented recreational aspects of land along streams or rivers. In addition, in the high risk fringe areas where significant flooding occurs less frequently, and where economics requires the use of the land, structures may be permitted with restrictions. Such restrictions would include establishing floor and utility elevations above known flood levels, controlling certain types of residential and institutional developments and placing prohibitions on the storage of flammable liquids and toxic chemicals within the area. Other provisions could be included to prevent creation of hazardous conditions.

40. ECONOMIC ANALYSIS. Local protective works consisting of earth levees, concrete flood walls, or a combination of both, are considered the most efficient structural measures for the protection of the areas that are subject to recurring flood damages. Modification or replacement of hydraulically inadequate bridges and culverts would be included as part of the local protective works where necessary. In those cases where Federal participation in construction of structural measures might be warranted or possibly be economically justified, the improvements were evaluated by an analysis of annual damages, total investments for flood control, average annual costs and total average annual benefits.

41. The derivation of estimated annual damages and benefits was based on preliminary methods of determining stage-damage-frequency relations. Those methods were sufficiently precise as to give an indication of the areas along the streams for which structural measures for flood control might be economically justified. Estimated costs for flood control works were not developed beyond the point where it became obvious that such works were not economically justified. Following that practice, the cost estimates prepared for the study were based on available data, rule-of-thumb methods and construction experience. Thus, unnecessary effort was not spent in developing and evaluating uneconomical plans of improvement. Summaries of the results of the economic analysis of the structural measures considered for each stream in the study area are presented in tables 14, 15, 16, 17, 18 and 19.

42. In lieu of providing flood protection through structural measures, flood damages and damage potential could be reduced through adoption of a flood forecasting system, a flood proofing program and flood plain management regulations. Those measures are described in paragraph 39b(2), 39b(3), and 39b(4), respectively. Because of their nature, an economic evaluation of the required non-structural measures is not warranted.

RESULTS OF INVESTIGATION

43. SUMMARY OF FINDINGS. The nature and character of developments in the study area, particularly along the upper reaches of the streams included in the study, have changed dramatically within recent years. Former farmlands have been converted into sprawling bedroom communities. Industry and commerce are also moving to outlying areas from the older sections that are located along the lower reaches of the streams. Despite this present trend of development in outlying areas, the older sections of the study area are almost completely saturated with respect to population and business activities.

44. The potential yield of present water supply sources in the study area is estimated to be sufficient to satisfy the foreseeable future demands of the population of the study area.

45. Low base stream flow combined with the discharge of effluent from industrial facilities and sewage treatment plants along the streams that flow through the study area have caused serious water quality problems. Development of a system for regional collection, treatment and disposal of both domestic and industrial liquid wastes is the most feasible means of reducing the water quality problem in the study area. The State of New Jersey adopted effluent quality standards and required full compliance with those standards by 1970.

46. The only known navigation problem in the study area involves the usage of Big Timber Creek by commercial shipping vessels of draft greater than existing project channel depth. Any improvement for navigation on Big Timber Creek should be planned and constructed under the special continuing authority of Section 107 of the River and Harbor Act of 1960, as amended.

TABLE 14
ESTIMATES OF FIRST COST - PLANS OF IMPROVEMENT
PENNSAUKEN CREEK
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
NORTH BRANCH			
Moorestown Twp.	Modification of series of dams located approximately 7.6 miles upstream of mouth of Pennsauken Creek.	—	a/
Moorestown Twp. & Maple Shade Twp.	Concrete flood walls along both banks of creek. Interior drainage facilities with pumphouse. Stream clearing.	over $1,000,000	b/
SOUTH BRANCH			
Evesham Twp. & Cherry Hill Twp.	Improvement of existing local storm drainage system.	—	Removal of silt deposits, accumulation of debris at culverts, channel encroachments and other such causes of flood problems related to lack of adequate maintenance is a local responsibility and does not provide sufficient justification for Federal participation under existing authorities. Therefore, estimate of first costs of improvements not prepared.
Cherry Hill Twp.	Earth levee	—	a/
Pennsauken Twp.	Concrete Flood Wall	—	a/

TABLE 14 (cont'd)
ESTIMATES OF FIRST COST - PLANS OF IMPROVEMENT
PENNSAUKEN CREEK
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
MAIN STEM			
Cinnaminson Twp.	Earth levee and concrete flood wall with pumping facilities for interior drainage.	over $500,000	b/
Palmyra Boro.	Concrete flood wall with interior drainage facilities.	over 350,000	b/
Cinnaminson Twp. & Palmyra Boro.	Tidal barrier with pumping facilities near mouth of Pennsauken Creek.	—	Limited ponding area upstream of barrier requires use of pumping facilities. See also footnote a/

a/ Recurrent flood damages in area obviously would not justify extensive improvements required to alleviate flood problem. Therefore, estimate of first costs of improvement not prepared.

b/ Not economically justified.

TABLE 15
ESTIMATES OF FIRST COST - PLANS OF IMPROVEMENT
POCHACK CREEK
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
Pennsauken Twp. a/ (Industrial Park)	See Remarks	—	Problem being resolved by State of New Jersey, Bureau of Water Control, which on 23 April 1968 issued an order re: Unauthorized Encroachment No. E-137. Order directs developer to install proper culverts throughout industrial park.
Pennsauken Twp. b/	See paragraph 23	—	

a/ Approximately 1.6 miles upstream of mouth of Pochack Creek.

b/ Approximately 0.6 miles upstream of mouth of Pochack Creek.

TABLE 16
ESTIMATES OF FIRST COST - PLANS OF IMPROVEMENT
COOPER RIVER
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
MAIN STEM			
Somerdale Boro.	Earth levee and bridge modification	—	a/
Haddonfield Boro.	Earth levee	—	a/
Cherry Hill Twp. b/	Earth levee and bridge modification	—	a/
Cherry Hill Twp. c/ and Collingswood Boro. - Haddon Twp.	Modification of dam located approximately 2.9 miles upstream of mouth of Cooper R.	—	a/
City of Camden	Earth levee and concrete flood wall along right bank of river	over $5,000,000	Not economically justified.
Cherry Hill Twp. c/ Collingswood Boro.- Haddon Twp.; City of Camden	Tidal barrier with pumping facilities near mouth of Cooper R.	—	a/ & d/
CHANDLERS RUN			
Pennsauken Twp.	Tidal barrier with pumping facilities or earth levee with extensive highway bridge modifications.	—	a/ & d/

a/ Recurrent flood damages in area obviously would not justify extensive improvements required to alleviate flood problem. Therefore, estimate of first cost of improvements not prepared.
b/ Approximately 8.5 miles upstream of mouth of Cooper R.
c/ Approximately 5 miles upstream of mouth of Cooper R.
d/ Limited ponding area upstream of barrier requires use of pumping facilities.

TABLE 17
ESTIMATES OF FIRST COST - PLANS OF IMPROVEMENT
NEWTON CREEK
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
MAIN STEM			
Haddonfield Boro.-Haddon Twp.	Modification of existing local storm drainage system.	$40,500	a/
Haddon Twp. b/	Modification of existing local storm drainage system.	—	a/ & c/
Haddon Twp. d/	Modification of existing local storm drainage system.	88,900	a/
Collingswood Boro.; Haddon Twp.-Audubon Park Boro.;City of Camden - Gloucester City; Haddon Twp. (South Branch); Gloucester City (South Branch).	Tidal barrier with earth levee and interior drainage facilities	—	Relatively low elevation of land adjacent to tidal barrier requires use of earth levee to prevent flood tides from passing around the barrier. See also footnotes c/ and e/.
SOUTH BRANCH			
Audubon Boro.	Modification of existing local storm drainage system.	—	a/ & c/
Audubon Boro.-Mt. Ephraim Boro.	Earth levee with interior drainage facility.	—	c/ & e/

TABLE 17 (cont'd)
ESTIMATES OF FIRST COST - PLANS OF IMPROVEMENT
NEWTON CREEK
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
SOUTH BRANCH (cont'd)			
Haddon Twp; Gloucester City	See "MAIN STEM"		
PETER CREEK			
Audubon Boro.	Modification of existing local storm drainage system.	--	a/ & c/

a/ Removal of silt deposits, accumulation of debris at culverts, channel encroachments and other such causes of flood problems related to lack of adequate maintenance is a local responsibility and does not provide sufficient justification for Federal participation under existing authorities.
b/ Approximately 5.5 miles upstream of mouth of Newton Creek.
c/ Estimate of first costs of improvements not prepared.
d/ Approximately 5.2 miles upstream of mouth of Newton Creek.
e/ Recurrent flood damages in area obviously would not justify extensive improvements required to alleviate flood problems.

TABLE 18
ESTIMATE OF FIRST COST - PLANS OF IMPROVEMENT
LITTLE TIMBER CREEK
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
Barrington Boro. a/	Modification of existing local storm drainage system.	—	Removal of silt deposits, accumulation of debris at culverts, channel encroachments and other such causes of flood problems related to lack of adequate maintenance is a local responsibility and does not provide sufficient justification for Federal participation under existing authorities. Therefore estimate of first costs of improvements not prepared.
Barrington Boro. b/	Earth levee	over $30,000	c/
Haddon Heights Boro.	Earth levee on right bank of creek.	—	d/
Mt. Ephraim Boro. e/	Concrete flood wall on right bank of creek.	over 120,000	c/
Mt. Ephraim Boro. f/	Earth levee on right bank of creek.	over 25,000	c/
Gloucester City	Earth levee on right bank of creek.	—	d/
Brooklawn Boro.	Earth levee on right bank of creek	—	d/

a/ North of Interstate Highway 295.
b/ South of Interstate Highway 295.
c/ Not economically justified.
d/ Recurrent flood damages in area obviously would not justify extensive improvements required to alleviate flood problem. Therefore, estimate of first costs of improvement not prepared.
e/ Approximately 2.5 miles upstream of mouth of Little Timber Creek.
f/ Approximately 2.2 miles upstream of mouth of Little Timber Creek.

TABLE 19
ESTIMATES OF FIRST COST - PLANS OF IMPROVEMENT
BIG TIMBER CREEK
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
MAIN STEM			
Bellmawr Boro. a/	Earth levee with interior drainage facilities.	over $100,000	b/
Bellmawr Boro. c/ & Brooklawn Boro.	Earth levee and concrete flood wall with interior drainage facilities.	over 800,000	b/
Westville Boro.	Earth levee and concrete flood wall with interior drainage facilities.	over 3,000,000	b/
Bellmawr Boro.; Brooklawn Boro. & Westville Boro.	Tidal barrier near mouth of Big Timber Creek.	—	Navigation requirements, limited ponding area upstream of barrier and preliminary analysis of possible benefits indicated that further consideration of tidal barrier was unwarranted.
NORTH BRANCH			
Somerdale Boro.	Modification of existing local storm drainage system and stream clearing and grading.	—	d/
BEAVER BROOK			
Barrington Boro. e/	Earth levee with interior drainage facilities.	over 50,000	b/

TABLE 19 (Cont'd)
ESTIMATES OF FIRST COST - PLANS OF IMPROVEMENT
BIG TIMBER CREEK
(July 1971 price level)

PROBLEM AREA	DESCRIPTION OF IMPROVEMENT UNDER CONSIDERATION	TOTAL FIRST COSTS (APPROXIMATELY)	REMARKS
BEAVER BROOK (Cont'd)			
Runnemede Boro. f/	Earth levee.	—	Recurrent flood damages in area obviously would not justify extensive improvements required to alleviate flood problem. Therefore, estimate of first costs of improvement not prepared.
Bellmawr Boro. & Runnemede Boro. g/	Modification of existing local storm drainage system.	—	Area formerly a swamp. Fill operations, construction of business sites and highway construction have taken place in area without improvements to local storm drainage facilities located downstream. See also footnote d/.

a/ Approximately 3 miles upstream of mouth of Big Timber Creek.
b/ Not economically justified.
c/ Approximately 1.5 miles upstream of mouth of Big Timber Creek.
d/ Removal of silt deposits, accumulation of debris at culverts, channel encroachments and other such causes of flood problems related to lack of adequate maintenance is a local responsibility and does not provide sufficient justification for Federal participation under existing authorities. Therefore, estimate of first costs of improvements not prepared.
e/ Approximately 3 miles upstream of mouth of Beaver Brook.
f/ Approximately 2.5 miles upstream of mouth of Beaver Brook.
g/ Approximately 2.1 miles upstream of mouth of Beaver Brook.

47. The study area has suffered frequently from floods and is subject to partial inundation in various localities from all types of storms including hurricanes, thunderstorms and prolonged periods of rainfall. To a great extent, the hazard of flooding has been, and is being, disregarded in the construction of new residential communities. Improvement of the drainage systems for disposal of storm runoff has not kept pace with the rapid change in the nature of development from rural to urban. Also, channel capacities have been reduced by encroachments for residential, commercial and industrial developments. In addition, the hydraulic capacities of the streams have been further reduced by the silting of culverts and the accumulation of debris such as down timber and discarded man-made material. Along the tidal reaches of the streams, the natural banks in many areas are too low to contain any stages greater than normal high tide stages.

48. Flood damage reduction measures given consideration in this study included both structural and non-structural measures. The structural measures that were evaluated included flood control reservoirs, tidal barriers, local protective works, bridge and culvert modifications, and channel improvements. The non-structural measures that were considered included evacuation and abandonment of flood prone areas, initiation of a flood forecasting system, utilization of flood proofing measures, and enactment of regulatory measures for control of the use of the flood plain.

49. Construction of local protective works and modification of bridges and culverts where necessary is the most efficient plan to utilize structural measures for the protection of the downstream reaches that are subject to tidal action. Replacement of hydraulically inadequate bridges and culverts is the most efficient plan to utilize structural measures for the solution of the flood problems in the upstream reaches that are not subject to tidal action. The nature and magnitude of recurrent flood damages that could be prevented along the tidal reaches of the streams are not commensurate with the costs that would be associated with providing flood protection through structural measures for those reaches. The nature of, and the solution to, the flood problems along the non-tidal reaches of the streams in the study area are such that the matter of providing flood protection for those reaches must be considered the responsibility of local interests.

50. The Corps of Engineers, working with and through the proper agency of the State of New Jersey, will provide, upon request, technical assistance and guidance in developing flood plain management programs. As part of that assistance and guidance, the Corps of Engineers will make flood plain information studies and issue reports on those studies.

51. Private interests have created numerous impoundments along the streams in connection with real estate developments and for recreational and industrial purposes. During the storm of 1 September 1940, many of the dams at those lakes failed with consequent devastating damages

from the resultant surges of streamflow. Although many of the dams have since been improved and many are equipped with gated outlet structures, maintenance of those structures has been inadequate. As a result, the controls do not function properly, if at all. Most of the lakes have little capacity for storage of flood flows. Also, there is no coordinated effort on the part of local officials or agencies to operate the lakes for flood control purposes effectively. The limited storage capacity, inoperable outlet controls and lack of a coordinated flood control procedure at times of heavy rainfall, constitute a potential for severe flood damage at communities downstream of the lakes.

52. In lieu of providing flood protection through structural measures, flood damages and damage potential could be reduced through adoption of all or part of the non-structural measures described in detail in paragraph 39b. Those non-structural measures must be considered the responsibility of local interests.

53. There are no known sites, structures or objects of historical, architectural or archaeological significance within the study area that qualify for preservation, restoration, maintenance, or enhancement under the provisions of Executive Order 11593.

54. As stated in this report, alternative measures of flood control were formulated and evaluated. It was found that those measures were either economically unjustified or the nature of the flood problem and the solution to those problems were such that there was no justification for Federal participation. Alternative standards would not provide a basis for departure from the report recommendations. Under those circumstances there is no basis for project analysis of the type called for in Senate Resolution 148, 85th Congress, 1st Session, adopted 28 January 1958. Therefore, no supplemental information is furnished with this report.

STATEMENT OF FINDINGS

55. I have reviewed and evaluated, in light of the total public interest, documents concerning the proposed action, as well as the views of other agencies and the general public, relative to the various alternatives in accomplishing improvements for flood control and allied purposes along the streams that flow through Camden County, New Jersey into Delaware River. The possible consequences of these alternatives have been studied and evaluated according to engineering feasibility, environmental effects, social well-being, and economic factors including regional and national development.

56. In consideration of these factors, the following points were considered pertinent to my review and evaluation:

a. Engineering Considerations. It has been found that the primary need of the study area in the field of water resources is for protection against flooding. The potential yield of present water supply sources in the study area is estimated to be sufficient to satisfy the foreseeable future demands of its population. Development of a system for regional collection, treatment and disposal of both domestic and industrial liquid wastes is the most feasible means of improving water quality in the study area. Recreational opportunities present in the study area are extensive and varied. Also, a report by the Camden County Planning Board recommended for acquisition or improvement of additional land to provide more parks and recreational open spaces by the year 1980.

Structural measures that could be used to reduce flood damages in the study area include tidal barriers with pumping facilities, local protective works such as earth levees, concrete flood walls and channel improvement, and replacement or modification of hydraulically inadequate bridges and culverts. The use of reservoirs for flood control purposes were also considered but it was found that all potential reservoir sites with sufficient capacity to control flood flows effectively had already been developed for recreational purposes. Modification of those reservoirs for flood control purposes rather than recreational purposes could only be accomplished at the loss of an important recreational asset in order to achieve limited flood reduction benefits. The study of the engineering feasibility of tidal barriers showed that, due to the topography of the study area, it would not be possible to store runoff upstream of the barrier from storms other than those of low intensity and relatively high frequencies. This condition would necessitate the use of extensive pumping facilities in order to obtain effective flood control. Construction of earth levees and concrete flood walls and modification of bridges and culverts has been shown to be the most efficient plan to utilize structural measures for the protection of the stream reaches that are subject to tidal action. Replacement of hydraulically inadequate bridges and culverts has been shown to be the most efficient plan to utilize structural measures for flood relief in the stream reaches that are not subject to tidal action.

In lieu of providing flood protection through structural measures, flood damages and damage potential could be reduced through adoption of non-structural measures. Non-structural alternative measures that were considered are evacuation of flood prone areas, adoption of a flood forecasting system, implementation of flood proofing measures and adoption of flood plain management regulations.

b. Environmental Considerations. The environmental factors that were considered in formulating and evaluating plans of improvement for the study area include land use, sewage disposal, fish and wildlife, recreational opportunities, and water quality.

The study area is located in the heart of the developing east coast megalopolis, an area that is becoming increasingly urbanized as land is developed rapidly by residential and business expansion. That rapid development in the study area and the accompanying change in land use are prime causes of the flood problems as improvement and maintenance of the area's drainage system has not kept pace with the change in the nature of development. Also, channel capacities have been reduced by encroachments for residential, commerical and industrial developments. Each of the various plans of improvement utilizing structural measures for flood control purposes, as well as adoption of a flood forecasting system or a flood proofing program, would permit continuation of the land development pattern that has evolved in the study area. Adoption of flood plain managment regulations would reduce flood damages and damage potential in the study area by regulating construction on and occupancy of the flood plains.

Effluent from sewage treatment plants in the study area are subject to quality standards adopted by both the Delaware River Basin Commission and the State of New Jersey. The quality of the effluent discharge would not be affected by any of the alternative means of providing flood control in the study area.

The fishery resources in the streams of the study area are presently not of significant value due to pollution and low streamflows. There are several marsh areas that presently provide habitat of value to waterfowl, however, anticipated developments in the study area would reduce the value of even those limited areas. Except for flood plain managment regulation, the various plans of flood control for the study area would not benefit the fish or wildlife of the study area. By controlling development in the flood plains, the remaining marsh areas could be preserved for the continued use of waterfowl.

Recreational facilities in the study area include parks, lakes, golf courses, country clubs, playgrounds, ballfields, picnic areas, swimming pools, a rowing course and a sailing course. Some of these recreational facilities are subject to flooding. The various structural measures considered for flood control in the study area would alleviate the problem of flooding of recreational areas. Flood plain regulation measures could possibly result in an increase in the acreage of land used for recreational purposes and therefore result in increased flood damage to recreational facilities.

Low base streamflow combined with the discharge of effluent from industrial facilities and sewage treatment plants into the streams that flow through the study area have caused serious water quality problems. Several of the streams in the study area are polluted to the extent that, during times of low flow, sewage treatment plant effluent represents 80 to 90 percent of the streamflow. Stream pollution has adverse effects on the fish and wildlife resources in Camden County, limits the water associated recreational potential of the streams and has the

potential for infiltrating into the aquifers that are the main source of the water supply of Camden County. In addition, the increase of nutrients in the stream, brought about by the sewage treatment plant effluent, enhances aquatic plant growth in sluggish backwater areas along the main channels which, in turn, has a secondary effect of increasing the insect population in those areas. Studies were made in order to determine the feasibility of developing reservoir sites to increase base streamflow and upgrade water quality. Nine sites in the study area were considered suitable as locations for reservoirs to augment base streamflow. Data on the probable regulated flows at those sites was furnished to the Federal Water Pollution Control Administration (now the Environmental Protection Agency) for review and recommendations. That agency submitted an unfavorable report on the proposed use of those sites. The Federal Water Pollution Control Administration found that the combination of shallow water, sunlight and nutrients in sewage effluents would result in aquatic plant growth that would be aesthetically objectionable and would also render the reservoirs useless for recreation and flow regulation purposes. As discussed previously, development of a system for regional collection, treatment and disposal of both domestic and industrial liquid wastes is the most feasible means of reducing the water quality problems in the study area. None of the alternative plans considered for flood control in the study area would increase base streamflow or upgrade water quality.

c. Economic Considerations. A balancing of economic costs and benefits has been accomplished through project formulation. In developing structural measures for flood control in the study area, economic consideration required maximum use of earthwork protection in lieu of concrete walls; alignment of flood control works to minimize necessary utility relocations; reasonable balance between cut and fill for channel realignment and construction of earth levees and concrete flood walls, and reduction of flood water surface elevations. Reduction of flood damages would be the primary benefit attributable to construction of flood control works in the study area. The primary intangible benefit associated with flood protection would consist of enhancement of the general welfare of the residents of the study area. Flood protection would also insure more nearly normal activity during flood periods with consequent intangible benefits to the communities and region at large. The economic analysis showed that Federal participation in construction of structural measures for flood protection along the tidal reaches of the streams in the study area is not economically justified.

Removal of silt deposits, accumulations of debris at culverts, channel encroachments and other such causes of flood problems related to lack of adequate maintenance is a local responsibility and does not provide sufficient justification for Federal participation under existing authorities. Therefore, an economic analysis was not made of those flood relief measures.

Adoption of non-structural measures to reduce flood damages and damage potential is a responsibility of local interests. Therefore, an economic analysis was not made of those protective measures.

d. Social Considerations. Implementation of any of the alternative flood control measures would obtain benefits through reduction of flood damages and would also increase the general welfare and security of the residents of the study area. None of the alternative structural measures would result in displacement of individuals or industry through construction of those works. Flood plain regulation measures would obtain a less chaotic development pattern in the study area with resultant improvement in the desirability of living there.

57. I find that the action, as proposed in my recommendations, is based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives; that the recommended action is consonant with national policy, statutes, and administrative directives; and that on balance the total public interest should best be served by its implementation.

CONCLUSIONS

58. GENERAL. The conclusions that have been reached as a result of this study are given in the following paragraphs.

a. Water Supply. Existing sources of water supply are adequate to supply future demands in the study area.

b. Water Pollution. Development of a system for regional collection, treatment and disposal of both domestic and industrial liquid wastes is the most feasible means of reducing the water quality problems in the study area.

c. Navigation. Improvements for navigation should be planned and, if economically justified, constructed under the special continuing authority of Section 107 of the River and Harbor Act of 1960, as amended.

d. Flooding.

(1) Federal participation in construction of structural measures for flood protection along the tidal reaches of the streams in the study area is not economically justified. Removal of silt deposits, accumulation of debris at culverts, channel encroachments and other such causes of flood problems related to lack of adequate maintenance along the non-tidal reaches of the streams in the study area is a local responsibility and does not provide sufficient justification for Federal participation under existing authorities.

(2) In lieu of structural measures, flood damages and damage potential could be reduced through adoption of non-structural measures that include a flood forecasting system, a flood proofing program and flood plain management regulations. Adoption of those non-structural measures is a responsibility of local interests.

RECOMMENDATIONS

59. I recommend that the Corps of Engineers not participate in the construction of improvements for the purpose of flood control along those streams that flow through Camden County, New Jersey into Delaware River. I further recommend that local interests:

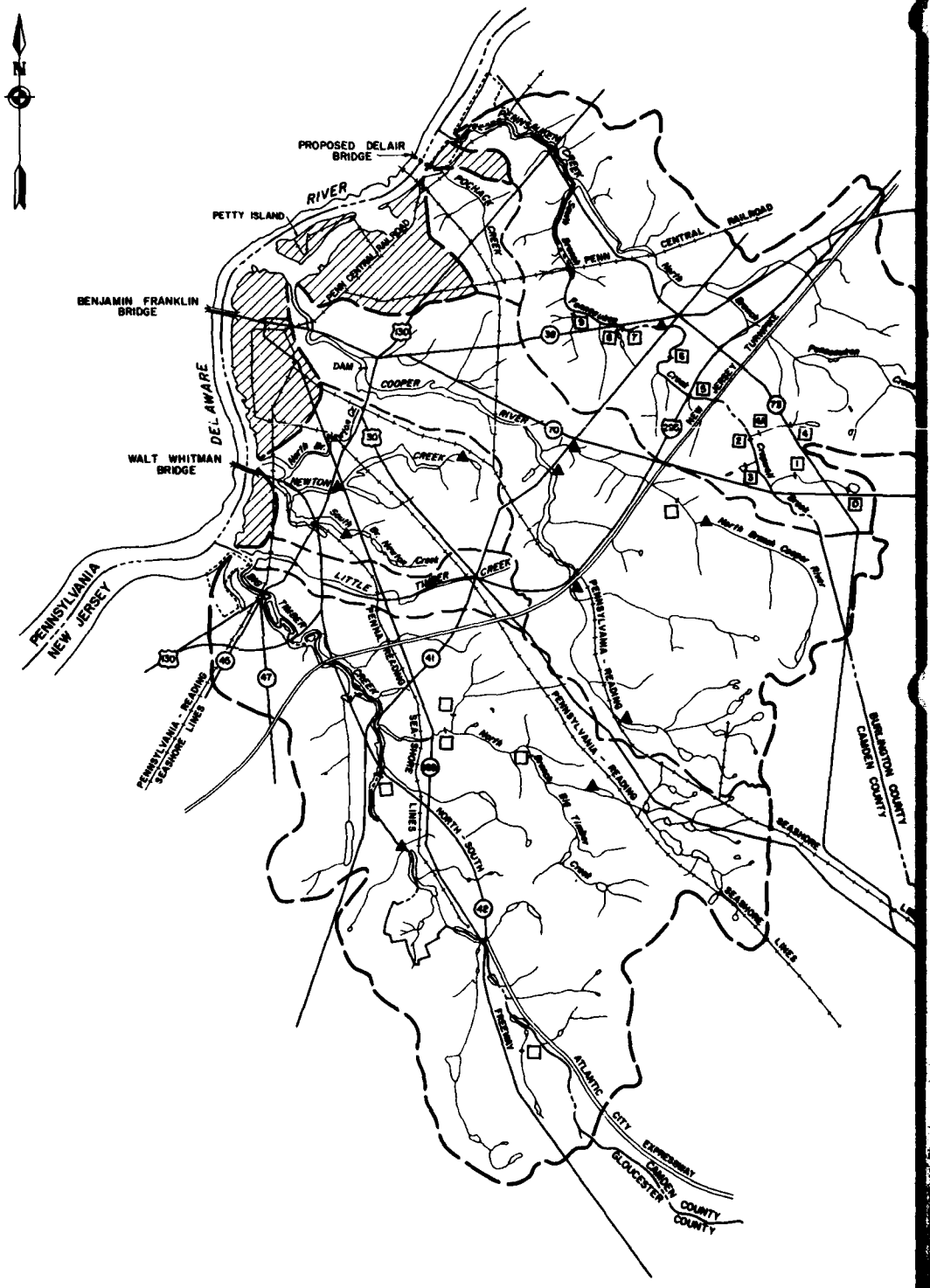
a. Replace hydraulically inadequate bridges and culverts to improve the drainage systems for disposal of storm runoff along the upper reaches of the streams in the study area.

b. Restore to full working order all outlet controls at dams across the streams in the study area, provide adequate maintenance to keep the controls functioning properly and develop a coordinated program to operate all lakes in such manner as to reduce the flood hazard at the time of heavy rainfall.

c. Undertake non-structural measures consisting of a flood forecasting system, a flood proofing program for existing structures and flood plain managment regulation.

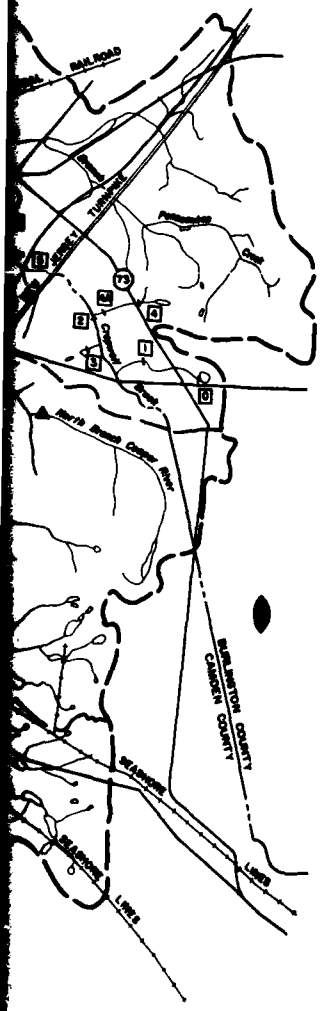
60. I also recommend that the State of New Jersey request the Corps of Engineers to provide engineering and other technical assistance and guidance in developing a management program for the flood plains along the streams in the study area.

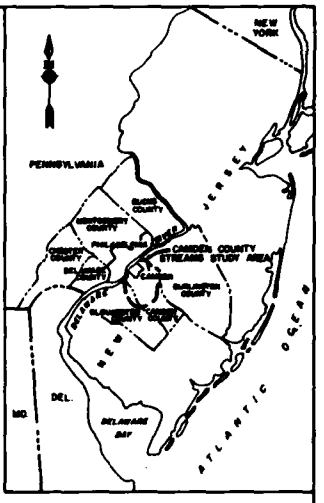
CARROLL D. STRIDER
Colonel, Corps of Engineers
District Engineer


N
PROPOSED DELAIR BRIDGE
PETTY ISLAND
RIVER
POQUESSING CREEK
POQUESSING CREEK
PENNSYLVANIA RAILROAD
PENN CENTRAL RAILROAD
BENJAMIN FRANKLIN BRIDGE
DELAWARE
DAM
COOPER
RIVER
WALT WHITMAN BRIDGE
NEWTON
CREEK
PENNSYLVANIA
NEW JERSEY
LITTLE
TIMBER
CREEK
PENNSYLVANIA - READING SEASHORE LINES
PENNSYLVANIA - READING
SEASHORE LINES
NORTH - SOUTH
FREEWAY
ATLANTIC CITY EXPRESSWAY
CAMDEN COUNTY
GLOUCESTER COUNTY
BURLINGTON COUNTY
CAMDEN COUNTY
SEASHORE LINES

LEGEND

- CAMDEN COUNTY STREAMS STUDY AREA BOUNDARY
- WATERSHED BOUNDARY
- STATE BOUNDARY
- COUNTY BOUNDARY
- RAILROAD
- STATE HIGHWAY
- U.S. HIGHWAY
- INTERSTATE HIGHWAY
- TOLL HIGHWAY
- U.S.G.S. STREAM GAGING STATIONS
- AREA DRAINING DIRECTLY INTO DELAWARE RIVER
- POSSIBLE IMPOUNDMENT SITES FOR LOW FLOW AUGMENTATION AS IDENTIFIED BY CAMDEN COUNTY PLANNING BOARD
- ADDITIONAL POSSIBLE IMPOUNDMENT SITES
- CORPS OF ENGINEERS DISPOSAL AREA





VICINITY MAP

SCALE IN MILES
30 0 30 60

SCALE IN FEET
5000 0 5000 10000 15000

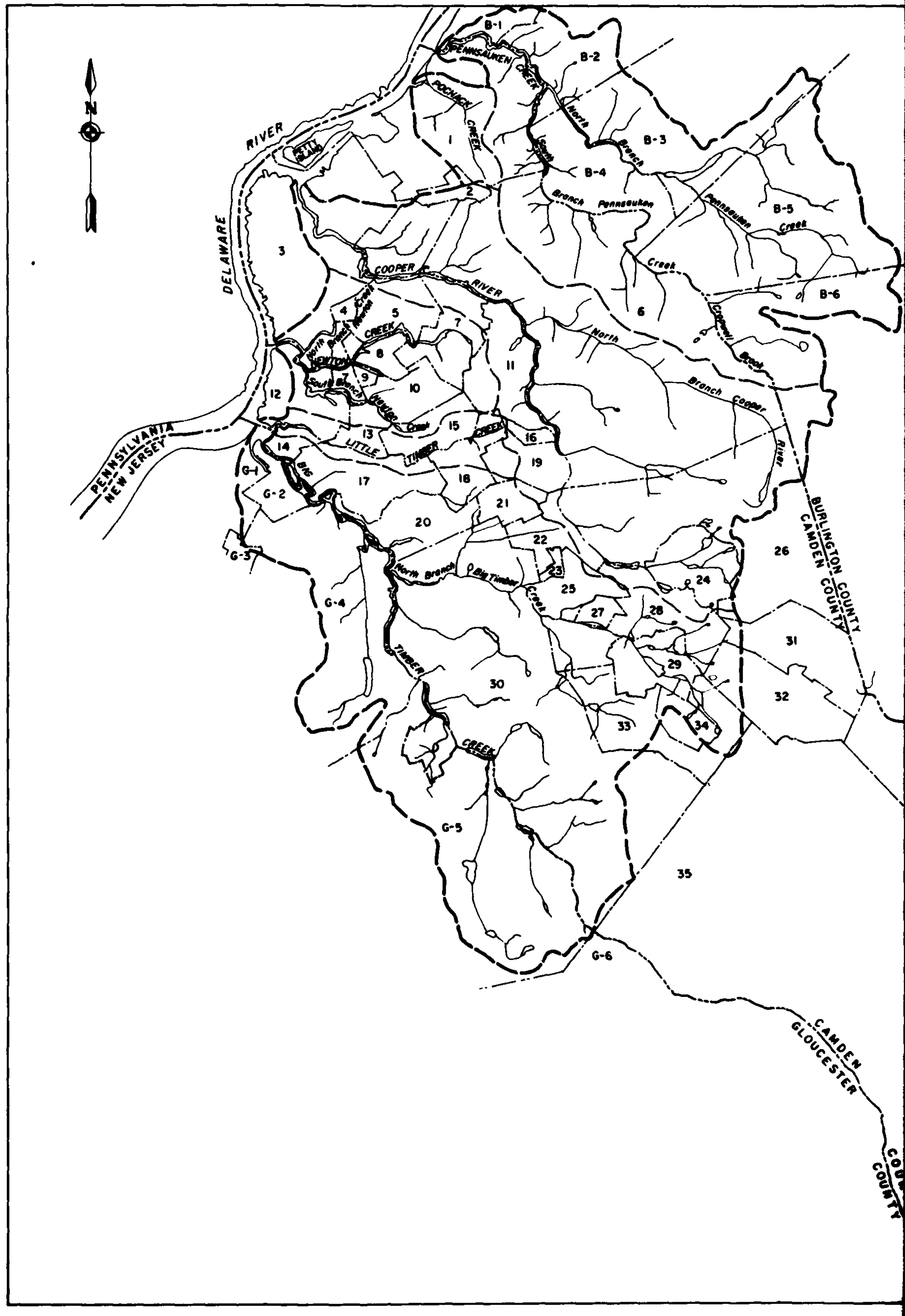
CAMDEN COUNTY STREAMS
NEW JERSEY
STUDY AREA

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

SUBMITTED	APPROVAL RECOMMENDED	APPROVED FOR THE DISTRICT ENGINEER
[signature]	[signature]	[signature]

DRAWN BY V H R	DATE APRIL, 1972	FILE NO 39802
CHECKED BY J A S	SCALE AS SHOWN	

TO ACCOMPANY REPORT DATED JUNE 1972 PLATE 1


N
DELAWARE
RIVER
PENNSYLVANIA
NEW JERSEY
PENNSAUKEN CREEK
POCHACK CREEK
North Branch
South Branch Pennsauken
Pennsauken Creek
Creek
COOPER RIVER
North Branch Cooper River
NEWTON CREEK
North Branch
South Branch
Newton Creek
LITTLE TIMBER CREEK
BIG
North Branch Big Timber Creek
TIMBER CREEK
BURLINGTON COUNTY
CAMDEN COUNTY
CAMDEN
GLOUCESTER
COUNTY
B-1
B-2
B-3
B-4
B-5
B-6
G-1
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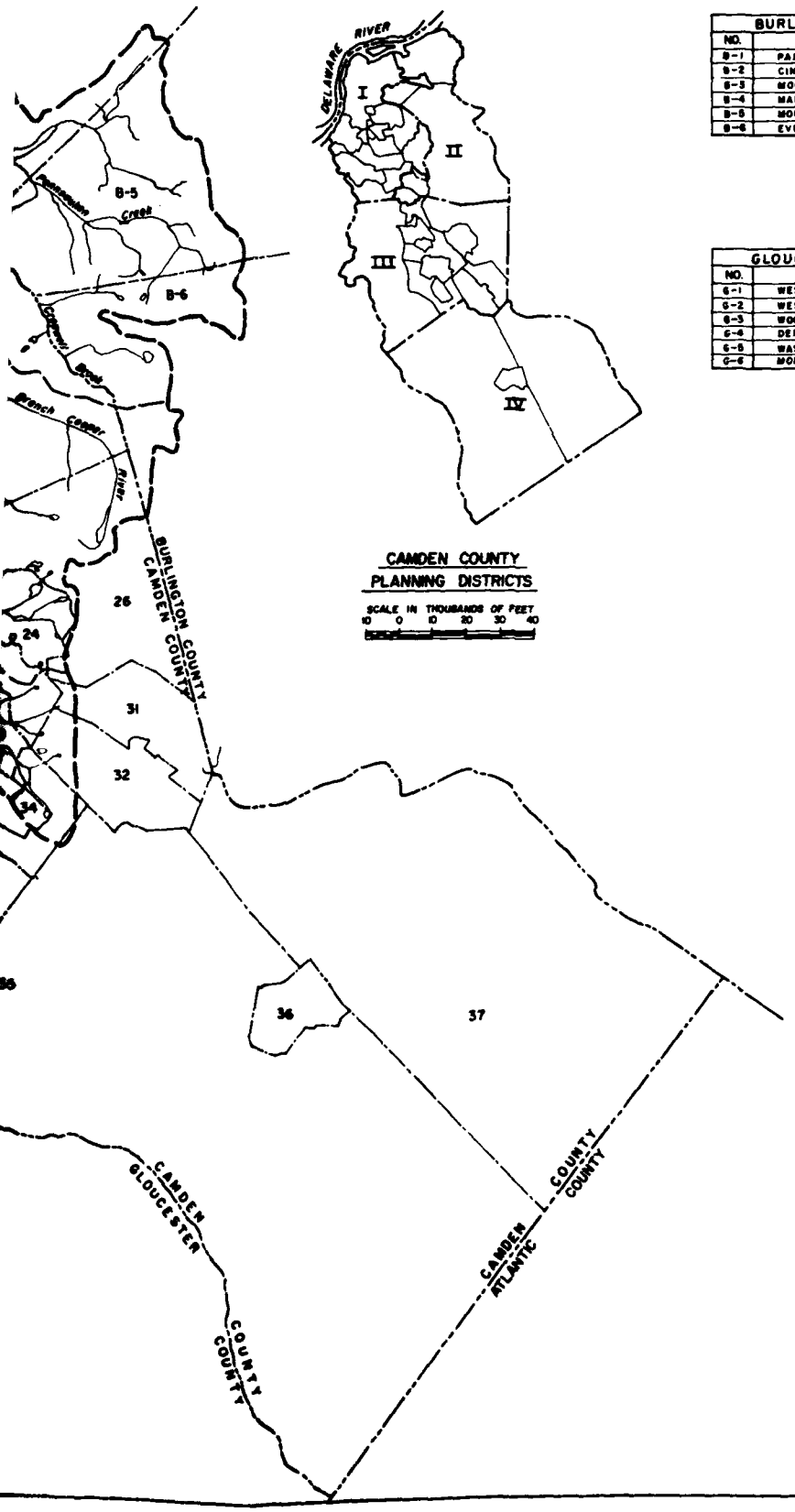

CAMDEN COUNTY
PLANNING DISTRICTS

SCALE IN THOUSANDS OF FEET
10 0 10 20 30 40

BURLINGTON COUNTY	
NO.	MUNICIPALITY
B-1	PALMYRA BOROUGH
B-2	CINNAMINSON TOWNSHIP
B-3	MOORESTOWN TOWNSHIP
B-4	MAPLE SHADE TOWNSHIP
B-5	MOUNT LAUREL TOWNSHIP
B-6	EVESHAM TOWNSHIP

GLOUCESTER COUNTY	
NO.	MUNICIPALITY
G-1	WEST DEPTFORD TOWNSHIP
G-2	WESTVILLE BOROUGH
G-3	WOODBURY CITY
G-4	DEPTFORD TOWNSHIP
G-5	WASHINGTON TOWNSHIP
G-6	MONROE TOWNSHIP

CAMDEN COUNTY		
NO.	MUNICIPALITY	PLANNING DISTRICT
1	PENNSAUKEN TOWNSHIP	II
2	MERCHANTVILLE BOROUGH	I
3	CAMDEN CITY	I
4	WOODLYNNE BOROUGH	I
5	COLLINGSWOOD BOROUGH	I
6	CHERRY HILL TOWNSHIP	II
7	HADDON TOWNSHIP	I
8	OAKLYN BOROUGH	I
9	AUDUBON PARK BOROUGH	I
10	AUDUBON BOROUGH	I
11	HADDONFIELD BOROUGH	I
12	GLOUCESTER CITY	I
13	MOUNT EPHRAIM BOROUGH	I
14	BROOKLAWN BOROUGH	I
15	HADDON HEIGHTS BOROUGH	I
16	TAVISTOCK BOROUGH	II
17	BELLMAWR BOROUGH	I
18	BARRINGTON BOROUGH	I
19	LAWNSIDE BOROUGH	II
20	RUNNEMEDE BOROUGH	I
21	MAGNOLIA BOROUGH	II
22	SOMERDALE BOROUGH	III
23	HI-NELLA BOROUGH	III
24	GIBBSBORO BOROUGH	III
25	STRATFORD BOROUGH	III
26	VOORHEES TOWNSHIP	III
27	LAUREL SPRINGS BOROUGH	III
28	LINDENWOLD BOROUGH	III
29	CLEMENTON BOROUGH	III
30	GLOUCESTER TOWNSHIP	III
31	BERLIN TOWNSHIP	III
32	BERLIN BOROUGH	III
33	PINE HILL BOROUGH	III
34	PINE VALLEY BOROUGH	III
35	WINSLOW TOWNSHIP	IV
36	CHESILHURST BOROUGH	IV
37	WATERFORD TOWNSHIP	IV

LEGEND

- CAMDEN COUNTY STREAMS STUDY AREA BOUNDARY
- WATERSHED BOUNDARY
- STATE BOUNDARY
- COUNTY BOUNDARY
- MUNICIPAL BOUNDARY

SCALE IN THOUSANDS OF FEET
5 0 5 10 15

CAMDEN COUNTY STREAMS
NEW JERSEY
MUNICIPAL PLAN

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

SUBMITTED | APPROVED AND RECOMMENDED | APPROVED FOR THE DISTRICT ENGINEER

CHIEF, PLANNING BRANCH | CHIEF, ENGINEERING DIV. | U.S. ARMY CORPS OF ENGINEERS

DRAWN BY V.W.B. | DATE: APRIL, 1972 | FILE NO. 39803
CHECKED BY J.J.S. | SCALE AS SHOWN

TO ACCOMPANY REPORT DATED JUNE 1972 PLATE 2